# THE "FIRST WILCOX SAND" OF NORTH-CENTRAL PAYNE COUNTY, OKLAHOMA

By

BRENDA SUE DULANEY

Bachelor of Science

University of Oklahoma

Norman, Oklahoma

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Name: Brenda S. Dulaney Date of Degree: May, 1987

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Scope of Study: At some localities in the area of investigation, T.19 N., R.2, 3, and 4 E., and T.20 N., R.2, 3, and 4 E., the "Wilcox" sandstones (Ordovician) are oil-producing units. This study examines the geologic setting and emphasizes depositional environments, petrology, and diagenetic features of the Wilcox on the Northeast Oklahoma Platform. Depositional environments were interpreted from cores, stratigraphic cross-sections and spontaneous-potential curve patterns. Petrologic and diagenetic features of the Wilcox were evaluated by means of thin-section examination, clay extraction and x-ray diffraction.

Findings and Conclusions: The Wilcox sandstones represent units that were deposited during fluctuations of the Simpson sea. The sandstones probably were deposited in nearshore, shallow marine environments.

Primary intergranular porosity ranges from a trace amount to 22 percent, as measured in thin sections and in core samples tested by Rotary Engineers Laboratories.

Two types of hydrocarbon-trapping conditions can be described for the Wilcox in the study area: anticlinal folding with four-way closure, and diagenetic products within the reservoir rock that act as an impermeable barrier.


ADVISOR'S APPROVAL Gary F. Stewart

THE "FIRST WILCOX SAND" OF

NORTH-CENTRAL PAYNE

COUNTY, OKLAHOMA

Thesis Approved:

Gary F. Stewart

Thesis Advisor

John W. Shelton

Zuhair al-Shaieb

John R. Helton

Thomas E. Grier

Norman N. Durham

Dean of the Graduate College

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# CHAPTER 1

# INTRODUCTION

## Location

The area of study includes a part of the Northeast Oklahoma Platform, T.19 N., R.2, 3 and 4 E., and T.20 N., R.2, 3 and 4 E. (Figure 1). The focus of this study is the "Wilcox" Sandstone, which is within the Simpson Group, Black Riveran Stage, Champlainian Series, Ordovician System (Figure 2).

## Objectives

The Wilcox sandstone is productive of oil and gas on the Northeast Oklahoma Platform. Its distribution, depositional environments, and trapping conditions have not been documented thoroughly in geologic publications.

The primary objectives of the study are as follows:

1. To describe the general diagenetic features of the Wilcox by a study of samples from the subsurface.
2. To develop a generalized paragenetic sequence of diagenetic events, based upon geochemical and cross-cutting relationships.
3. To interpret general depositional environments of the Wilcox sandstones based on evidence from cores,

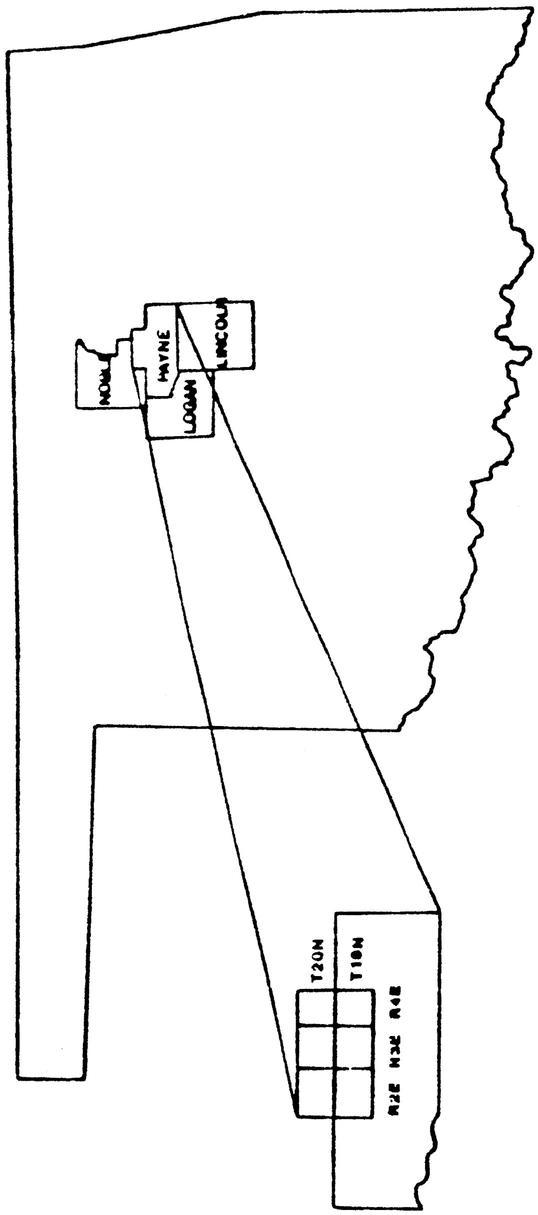



Figure 1. Location of Study Area

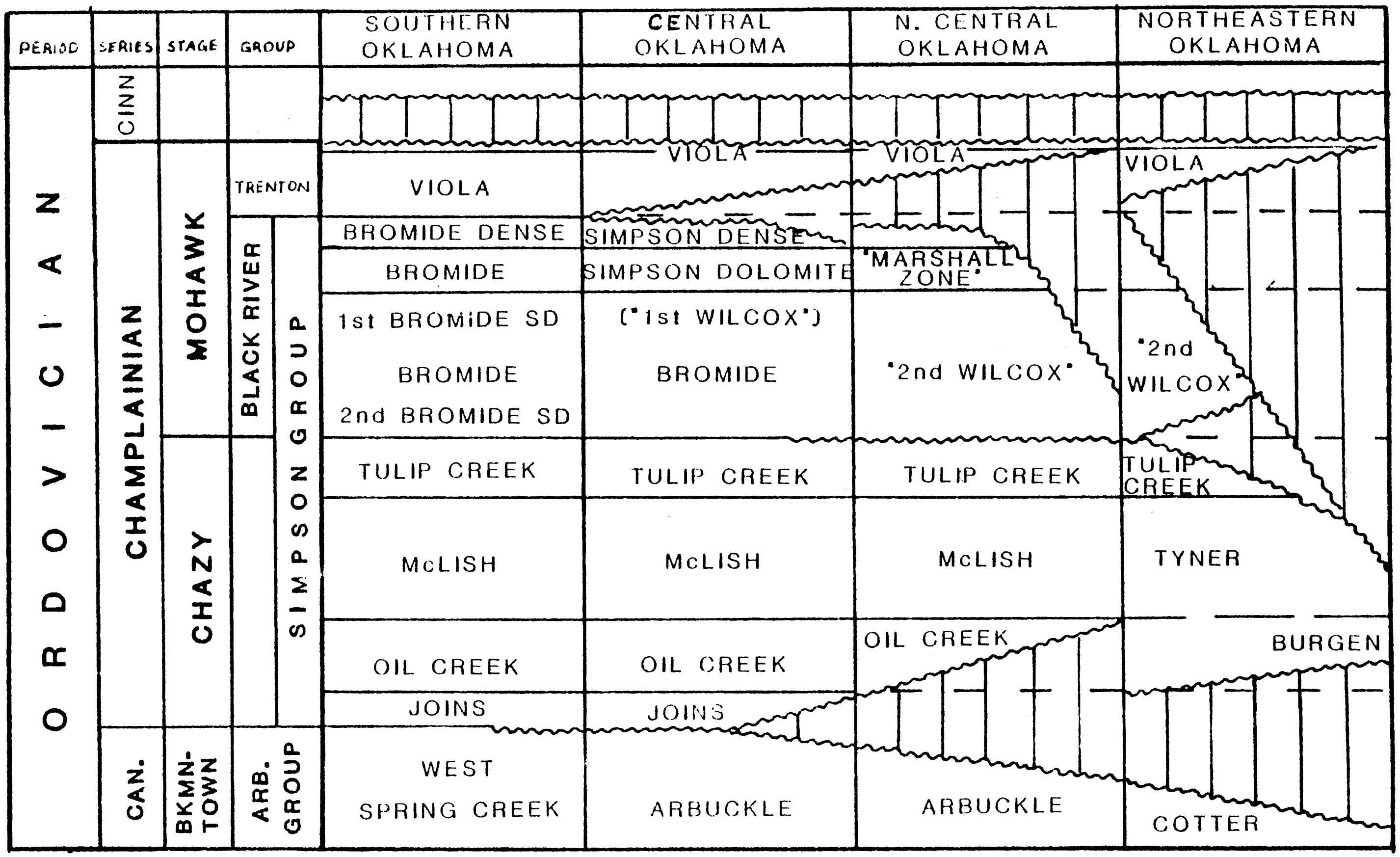



Figure 2. Generalized Stratigraphic Column of Ordovician Strata in Oklahoma (after Cronenwett, 1956).

maps, and from work by previous authors.

4. To document the kinds of petroleum traps developed in the Wilcox in the study area.
5. To document the productivity of Wilcox oil and gas fields within the study area.

## Methods of Investigation

Data utilized in this study were obtained from several sources:

1. Literature published on the Simpson Group was reviewed extensively.
2. Two stratigraphic cross-sections were constructed to show lateral and vertical facies variations of the Simpson Group.
3. Six maps were constructed, including structural contour maps of the top of the Mississippi Lime, top of the Viola Limestone, and top of the First Wilcox Sand, along with an isolith map of the Sylvan Shale, an isopach map of the Misener, Hunton, and Sylvan section, and an isolith map of the Wilcox Sand. These maps were used to show facies relationships and the geometries of rock-stratigraphic units.
4. Five cores were sampled and logged in detail.
5. Eighty-four thin sections were examined for types and abundances of detrital grains, matrix constituents, diagenetic cements, authigenic clays and porosity.

6. X-ray diffraction of powdered samples and x-ray diffraction of clay extractions were used in conjunction with petrographic analysis for identification of constituents.

## Previous Investigations

The "Wilcox" Formations of Middle Ordovician age were named after Harry Wilcox or Wilcox Oil and Gas Company, who developed production in No. 1 Gracie Call, section 3, T.16 N., R.13 E., Bixby field, Tulsa County on April 29, 1914 (Aurin, Clark and Trager, 1921). According to Jordan (1957), the terms "Mounds sands" should be used for uncorrelated Simpson sands of the Tulsa area, "Seminole sands" should be used in the Seminole area, "First Wilcox" should be used in the Stillwater area, and the "First Wilcox" of Central Oklahoma should be called "Upper or First Bromide sand".

The Simpson Group of northeastern Oklahoma has been studied by numerous geologists, including Taff (1902), Ulrich (1911), Decker and Merritt (1931), and Levorson (1928). A complete summary of Ordovician formations of northeastern Oklahoma was completed by Montgomery in 1951. Disney and Cronenwett (1955) and Cronenwett (1956) made an excellent preliminary regional investigation of the Simpson Group, correlated subsurface formations with Decker's recognized outcrop sections, and illustrated the relationship between those formations and subsurface producing "sands". Stark

(1961) correlated the lower part of the Tyner Formation of northeastern Oklahoma with the Oil Creek Formation (upper part) of southern Oklahoma on the basis of an Oil Creek faunule, and assigned the Burgen Sandstone to the stratigraphic position of the Oil Creek sand, an assignment which had previously been suggested by Cram (1930) and by Disney and Cronenwett (1955). An extensive paleogeologic and quantitative lithofacies analysis of the Simpson Group of Oklahoma was published by Schramm in 1964.

The Wilcox strata of the Simpson Group in northeastern Oklahoma have not been the specific focus of research. These rock units usually are considered to be constituents of either the Tulip Creek Formation or the "Bromide" sand and previously have not been investigated in detail.

# CHAPTER II

# GEOLOGIC SETTING

## Tectonic Features

In order to understand fully the tectonic processes that affected deposition of the Wilcox sandstones during the Ordovician, an overview of the regional tectonic setting is in order.

The area of study is located on the Northeast Oklahoma Platform (Figure 3). The platform is bounded by the Cherokee Basin to the north, the Arkoma (or McAlester) Basin to the south, the Ozark Uplift to the east, and the Nemaha Ridge to the west.

The Northeast Oklahoma Platform and the Cherokee Basin were relatively stable during the Paleozoic, as evidenced by a north-northwest strike and fairly uniform thicknesses of time-stratigraphic markers present in the shelf area (Akmal, 1950). Regional dip in the study area averages about 100 feet per mile.

The Arkoma Basin is an arcuate tectonic element between the Ozark and Ouachita Mountains (Figure 3) (Sutherland and Manger, 1979). Subsidence began late in Morrowan time; a positive trend from the southeastern extension of the Ozark Uplift through southeastern Arkansas existed during the

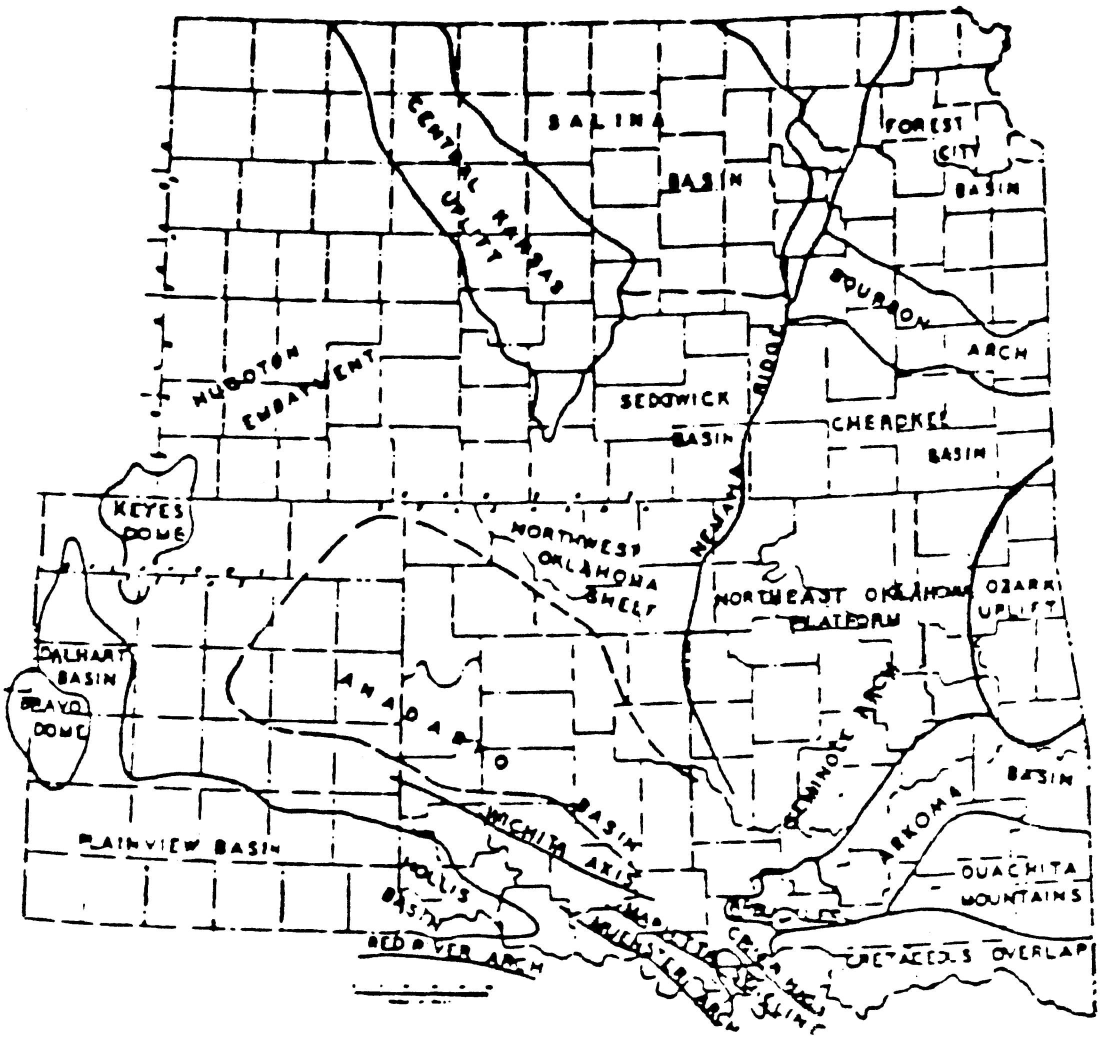



Figure 3. Tectonic Features of the Southern Mid-continent continent Region (after Huffman, 1960).

Paleozoic (Barrett, 1986). As a consequence, the development of sands and dolomites in this interval is highly erratic.

Movements originating in the region occupied by the Ozark Uplift (Figure 3), which extends into southeastern Kansas and western Missouri, are suggested by the pronounced northward thinning of Simpson units (Cronenwett, 1956). Unconformities, which are best developed in this direction, suggest gentle pulsations with a source towards the northeast (Cronenwett, 1956).

A zone of faulted anticlines that were uplifted between Early Mississippian and Late Pennsylvanian comprise the Nemaha Ridge. It extends from Nebraska to Oklahoma and Precambrian basement rocks are at shallow depths throughout the length of this ridge (Cole, 1955).

## Tectonic History

Dapples (1955) suggested that strata of the Simpson Group represent only a small portion of Lower Ordovician deposits that are widespread over much of the central interior of the United States, and that are similar lithologically.

The Simpson basin, or Arbuckle geosyncline, had its inception in Late Cambrian, with downwarping of the basement complex to form a narrow, linear depositional belt (Figure 4). Following deposition of the Reagan Sandstone and approximately 7,000 feet of Cambro-Ordovician Arbuckle carbonates, eustatic withdrawal of the Canadian sea followed by subaerial erosion produced a widespread irregular surface throughout the

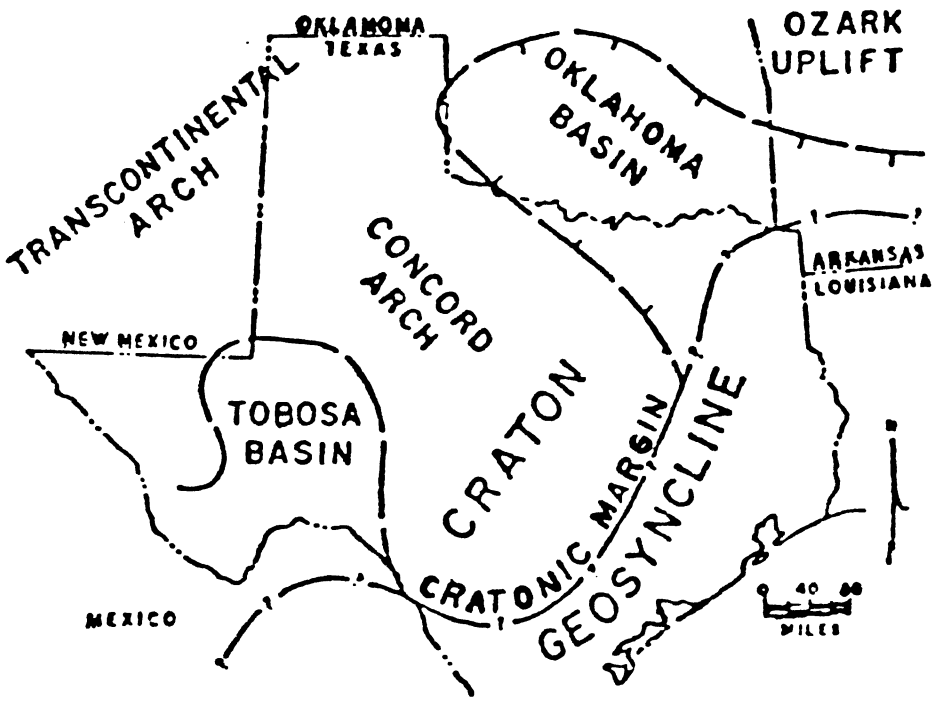



Figure 4. Major Uplifts and Basins of the Southern Midcontinent during Late Cambrian through Devonian time (after Nicholas and Rozendal, 1975).

Mid-Continent region. The duration of this period of non-deposition is uncertain (Cronenwett, 1956).

In early Chazyan time, subsidence of the basin recurred. Depositional conditions similar to those that prevailed during deposition of the Arbuckle existed. During Late Chazyan time, more pronounced subsidence of the basin and a concurrent rise in sea level was accompanied by influx of vast quantities of clastics into Oklahoma. Within the Northeast Oklahoma Platform, sands were introduced from the east and were limited by onlap upon Arbuckle strata in northwestern Oklahoma (Longman, 1981). Ultimately, these sands were derived from the Canadian Shield (Dapples, 1955). A slight regression of the Chazyan sea led to removal of a portion of the lower unit within the Simpson Group (Statler, 1965).

Renewed transgression of the Simpson sea in Black Riveran time and influx of clastics from the east produced a depositional environment similar to the Chazyan. However, deposition of sands were limited to the northeastern rim of the basin, and interfingering limestones, dolomites, and thin sandstones in varying proportions occurred on the Northeastern Oklahoma Platform (Schramm, 1964). The Seminole Uplift diverted the basal, regression southward through Oklahoma where a wedge of sand was transported into the southeastern Seminole Basin, northward along the western edge of the Central Oklahoma Uplift (Figure 5).

During Late Black Riveran time, vast quantities of sand were derived from eastern Oklahoma and the north-central

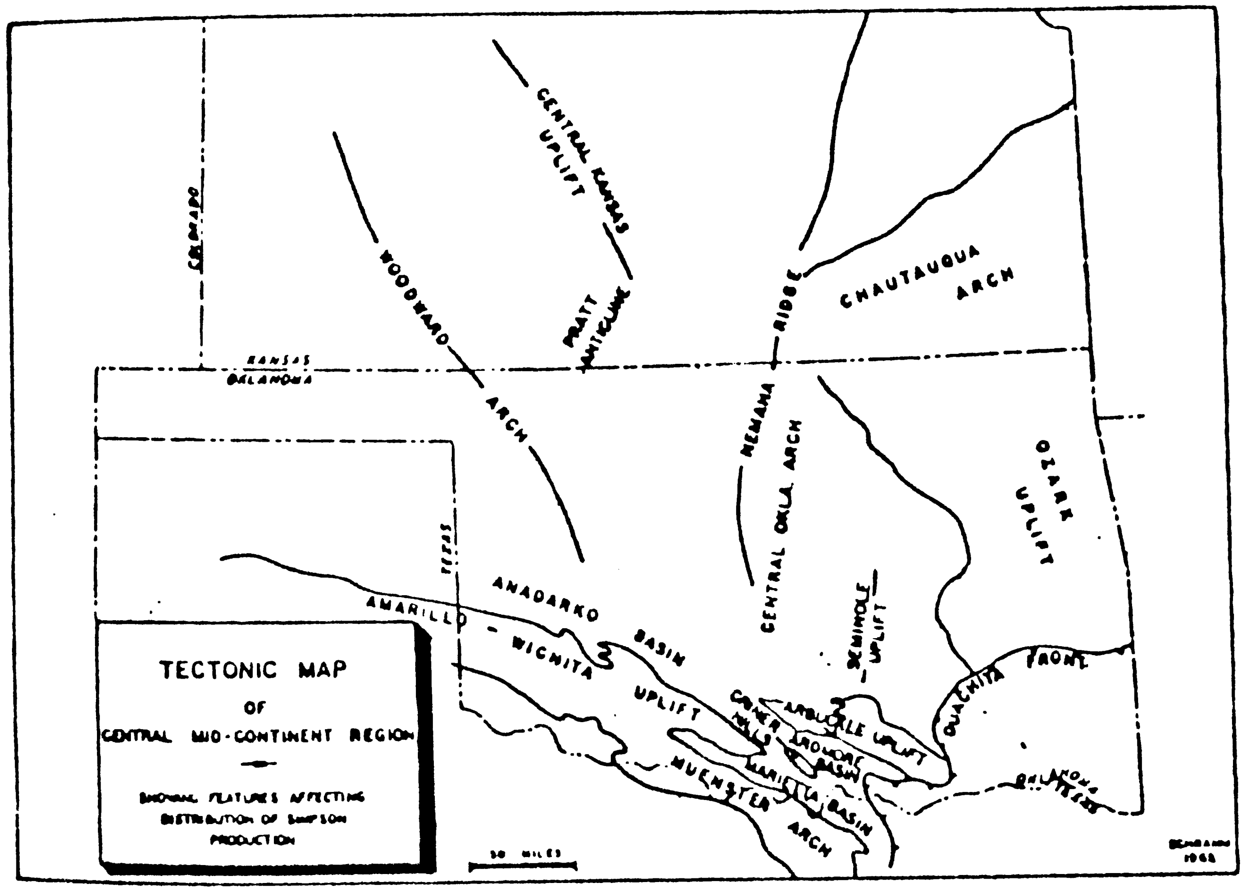



Figure 5. Tectonic Map of Central Mid-continent Region (after Schramm, 1965).

United States as a result of a major pulsation of the Ozark Uplift (Holden, 1965). These sands spread over Oklahoma except upon the southern shelf of Oklahoma (Figure 6). Slow regression of the sea promoted formation of carbonate sediment, the limestones and dolomites of the Upper Black Riveran units (Montgomery, 1951). A brief interval of erosion and truncation created by mild epeirogenic uplift and the withdrawal of the sea into the deepest part of the Seminole Basin and into the Ouachita geosyncline is made evident by erosion of Late Black Riveran strata.

Lower Mohawkan time was marked by an extremely quiet or "nontectonic" period whereas most of the older formations were cyclically deposited in relatively shallow waters under stable conditions (accompanied by oscillation on the shelf), the Late Mohawkan sediment was a calcareous ooze, deposited by precipitation in extremely quiet waters (Schramm, 1964). The Trenton sea inundated the region during a brief cessation of the Ozark Uplift (Figure 7).

## Depositional History

As discussed previously, the Northeast Oklahoma Platform was relatively stable throughout Ordovician time. Fluctuations of the Simpson sea are recorded by the alternating sequence of sandstones, shales and thin limestones. The Simpson Group is as thick as 2,300 feet in the Arbuckle Mountains, but diminishes to less than 200 feet on the Northeast Oklahoma Platform (Akmal, 1950). More

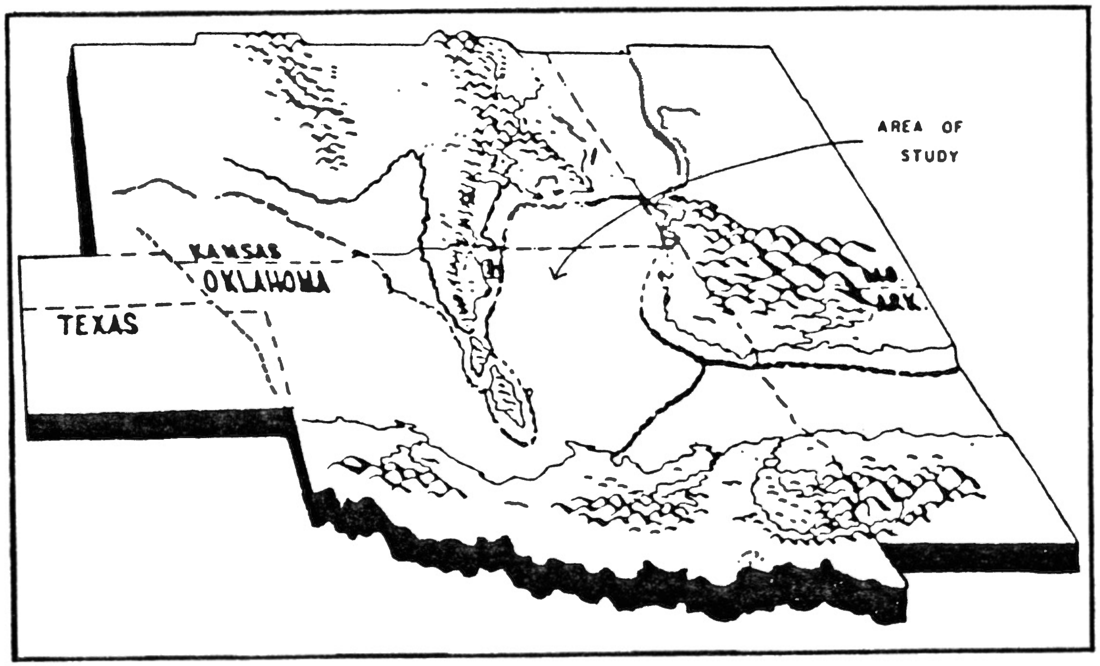



Figure 6. Generalized Paleotopography of Oklahoma

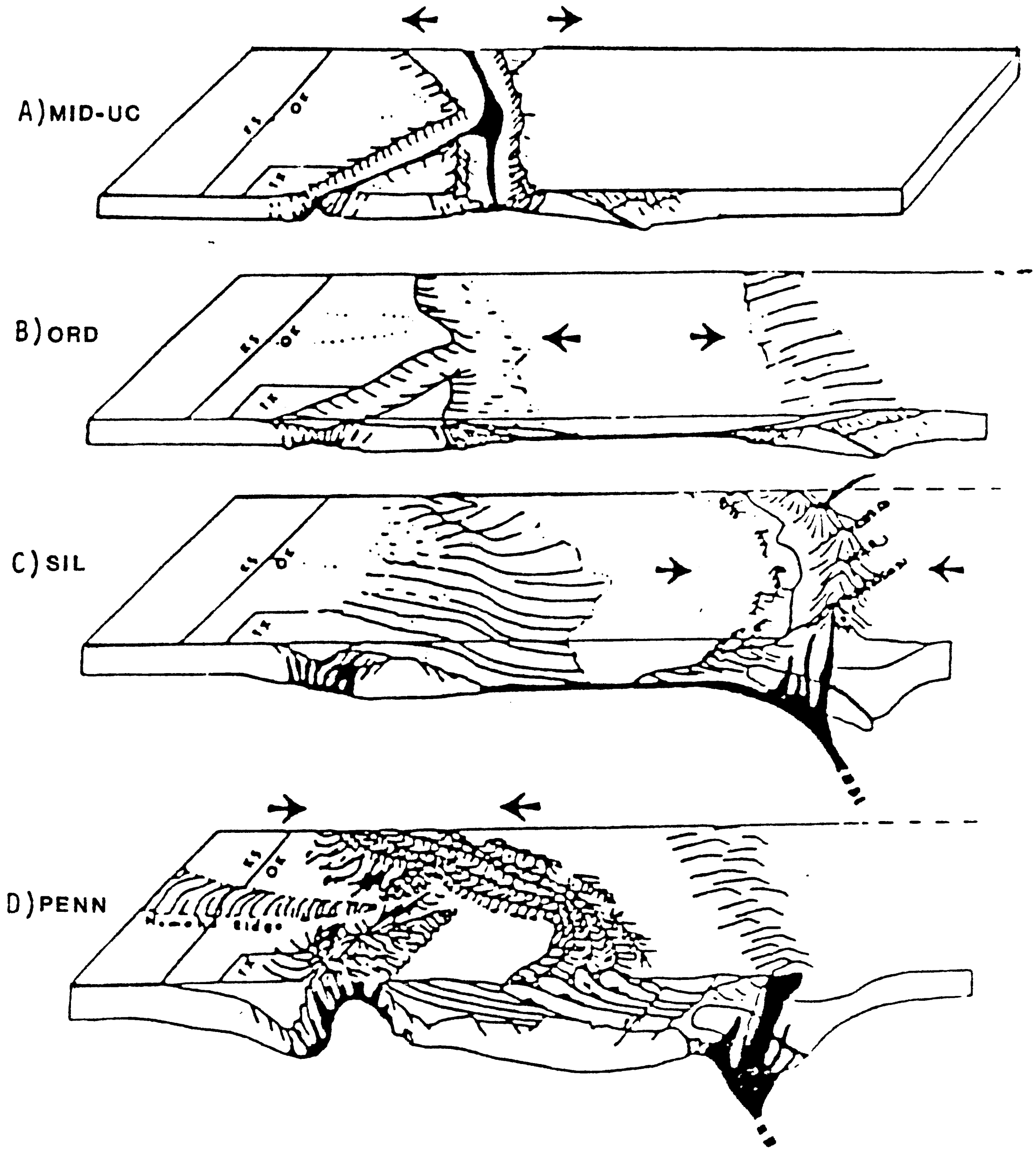



Figure 7. Generalized Sketch of the Tectonic Evolution of Oklahoma (Greatly modified from Briggs and Roeder, 1975).

specifically, the Simpson Group thickens from less than 100 feet in the northeastern part of Payne County to approximately 500 feet in the west (Shelton, Ross, Garden, and Franks, 1985).

A feature of the Simpson Group in Oklahoma is its lateral gradation from shales and limestones in southwestern and western Oklahoma, to the greater amounts of sandstone in the vicinity of the Arbuckle Mountains, to the moderate sandstone-to-limestone ratio toward the Ozark Uplift, and into the Womble Shale with its Blakely Sandstone of the Ouachita facies (Figure 8) (Holden, 1965). The lack of sands in the southwest and west is explainable by the fact that carbonate rocks of the underlying Arbuckle Group, which may have served as sources, were practically devoid of sandstone. The sandpoor condition of the Ouachita facies, Middle Ordovician section, is attributed to its distance from the source area, coupled with deeper marine environments, where mostly silts and fine clay from the continental margin were deposited (Barrett, 1986).

Figure 9 shows generalized paleogeography and paleoenvironments of the Middle Ordovician Simpson Group. Early Ordovician rocks of the Northeast Oklahoma Platform primarily are thin-bedded, light to dark gray limestones, interbedded green and maroon shales with thin sandstones. Characteristically, these facies occur in transgressive-regressive couplets. Thin transgressive limestones are indicative of relatively stable water depth and low sediment

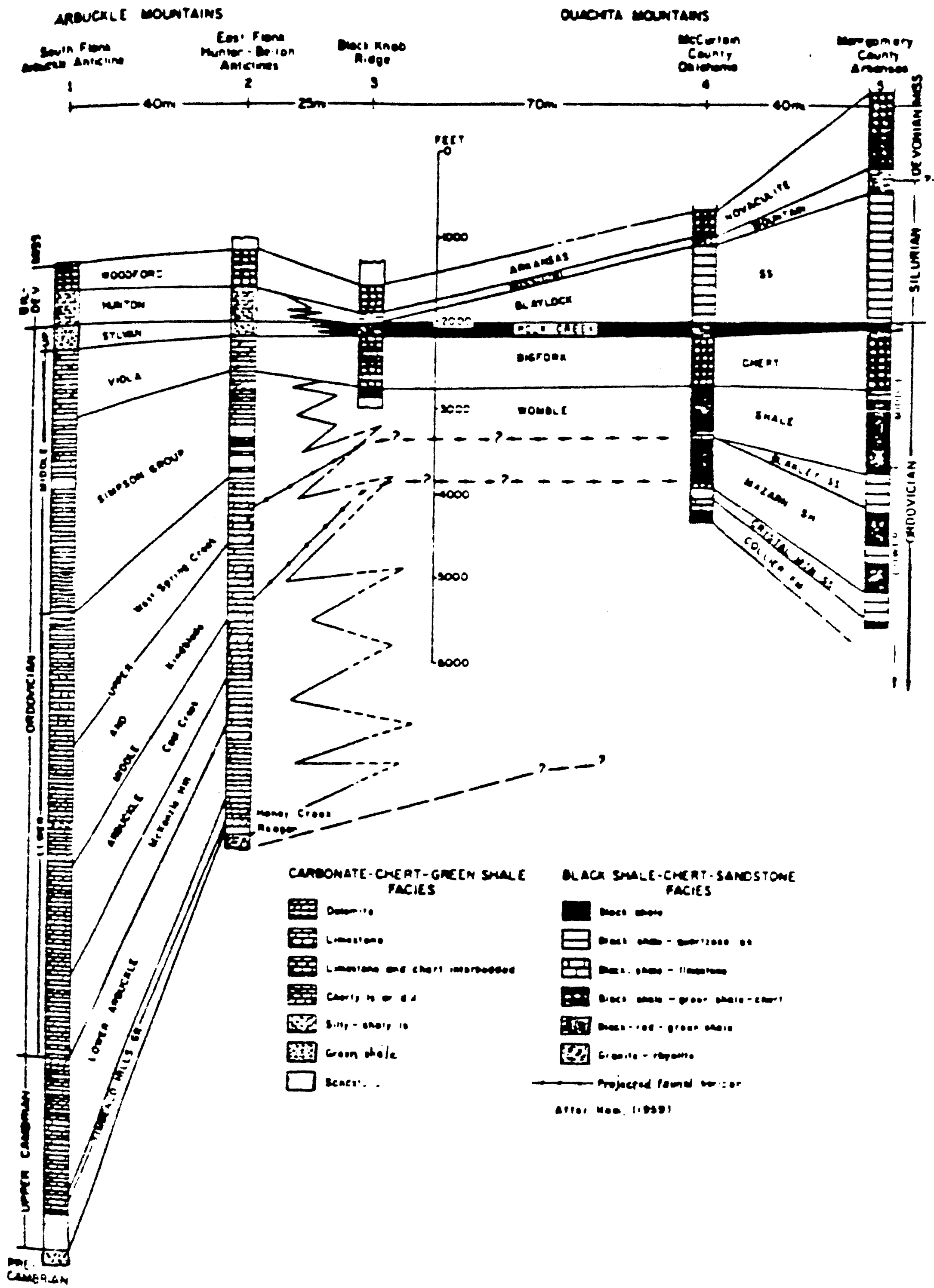



Figure 8. Cross-section showing Lateral Facies Relationships of the Simpson Group (after Ham, 1959).

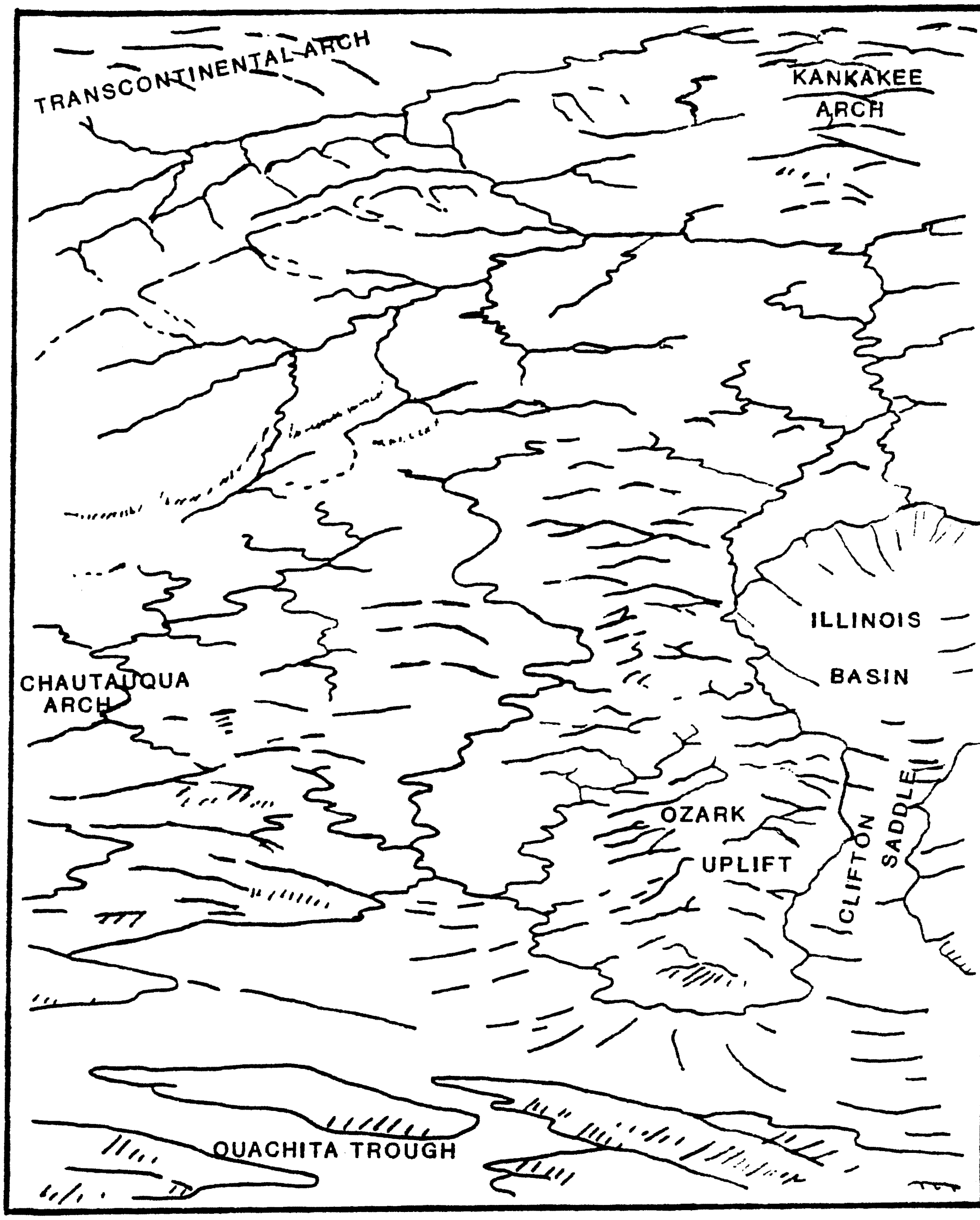



Figure 9. Hypothetical Overview of the Midcontinent region in Late Middle Ordovician, Showing Relative Positions of the Ozark Uplift and Illinois Basin (adapted from Koenig, 1967). (Deposition of Wilcox sandstone is not implied by position of the seaway).

influx. The presence of dark shales suggests shallow, stagnant environments with low to moderate influx of sediment (Albano, 1975). Cronenwett (1956) suggested that maroon shales resulted from shallow-water oxidizing conditions during sporadic periods of emergence. Sandstones principally are considered to be fluvial-deltaic and to represent remnants of ancient drainage patterns with the primary sources for the sands having been from the east. According to Schramm (1964), these sands appear to be redistributed and concentrated as the result of shoaling effects along the Central Oklahoma Arch.

The Upper Ordovician units suggest the cyclic arrangement characteristic of most of the other Simpson formations: lower sandstone member, middle section of green shales, and uppermost thin to massive limestones. These massive limestones record submergence by transgressive seas that inundated most of the Mid-Continent.

## Stratigraphy

### Introduction

For the purposes of this paper, stratigraphic descriptions will be limited primarily to the upper units of the Simpson Group, Champlainian Series, Ordovician System (Figure 2). In ascending order, the five formations that compose this group are: Joins, Oil Creek, McLish, Tulip Creek, and Bromide. In the study area, the exact correlation between the "First" and "Second Wilcox" formations and the aforementioned Simpson Group is open to question. Barrett

(1986) suggested that the Second Wilcox (Figure 2) is equivalent to the "Third Bromide" or Tulip Creek. However, according to Cronenwett (1956), the Bromide is a massive sandstone termed the "Second Wilcox Sand" on the Northeast Oklahoma Platform. In addition, the "First Wilcox" Sandstone in north-central Oklahoma apparently is only a coarse-grained facies and does not correlate with the "First Wilcox" of central Oklahoma (Cronenwett, 1956). For this reason it is placed in parentheses in the stratigraphic column (Figure 2). Overlying this sandstone are dolomitic strata generally referred to as the "Simpson Dolomite", which underlie limestone that marks the top of the Simpson Group (Figure 2). This "Simpson Dolomite" corresponds to the "Bromide Dense" of southern Oklahoma (Schramm, 1964). According to Cronenwett (1956), the "Simpson Dolomite" of central Oklahoma is also termed the "Marshall zone", and the "First Wilcox" is placed above this zone (Figure 2). In summary, the "Second Wilcox" sandstone, the Marshall zone, the First Wilcox sandstone, the Simpson Dolomite, and the "Dense Limestone" are thought to be equivalent to the Bromide Formation throughout most of Oklahoma (Shelton, Ross, Garden and Franks, 1985).

<u>Joins Formation</u>

The Joins Formation was named by Ulrich (1928), and is considered to be the basal formation of the Simpson Group (Figure 10). According to Schramm (1964), the Joins consists of thin-bedded light to dark gray limestones and less abundant

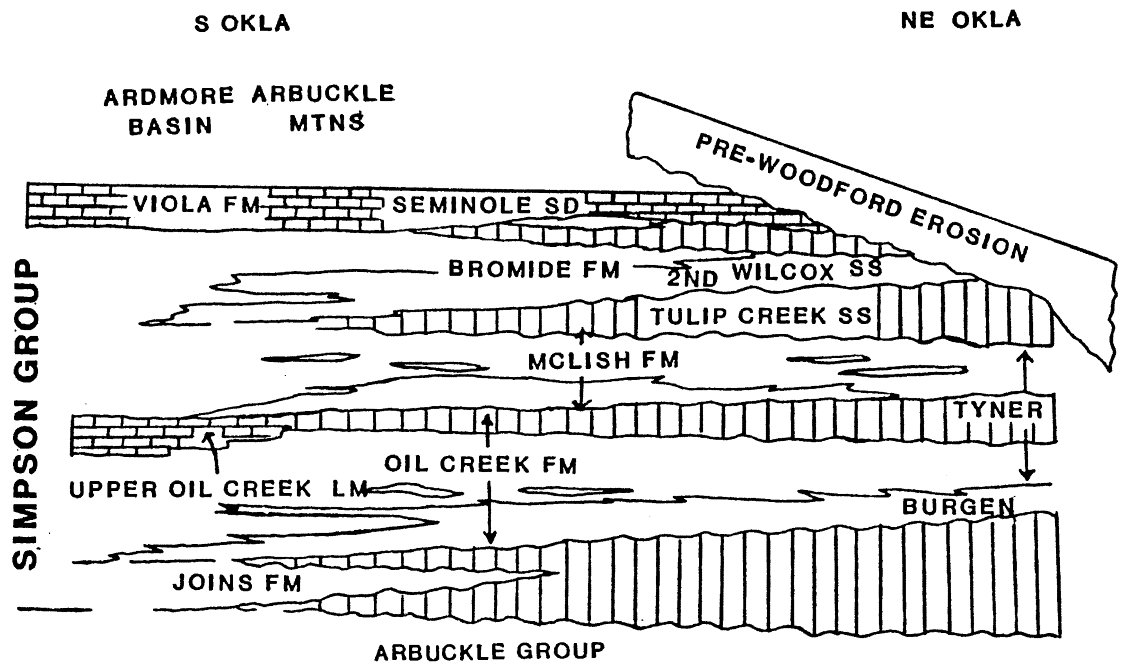



Figure 10. Diagrammatic Cross-section Showing Postulated Stratigraphic Relationships in the Study Area (after Statler, 1965).

dark green shales, with intraformational conglomerates near the base.

Decker (1931) described the conglomeratic base as consisting of angular pieces of limestone and well-rounded chert pebbles. The Joins Formation thins northward and is believed not to be present in north-central and northeastern portions of Oklahoma (Figure 11).

Oil Creek Formation

The Oil Creek Formation conformably overlies the Joins Formation, and consists of a basal sandstone member and an upper member of interbedded green shales and thin-bedded, coarsely crystalline limestones. According to Schramm (1964), the basal sandstone member is restricted essentially to eastern Oklahoma, and is absent elsewhere owing to both onlap and facies change. Also, very little limestone or dolomite was deposited throughout the shelf area. The basal sandstone of the Oil Creek is gray to white and is composed of well-sorted, subangular, fine-grained quartz. Near the base, thin black shale partings with pyrite crystals are common. The cement predominantly is dolomite (Schramm, 1964).

Limestones of the Oil Creek thin gradually northward and are replaced by dolomite, shales and sandstones. Dolomites that replace limestones with increasing frequency upward in the stratigraphic section are finely sucrosic and range from light gray to light brown. Because the crystals of dolomite

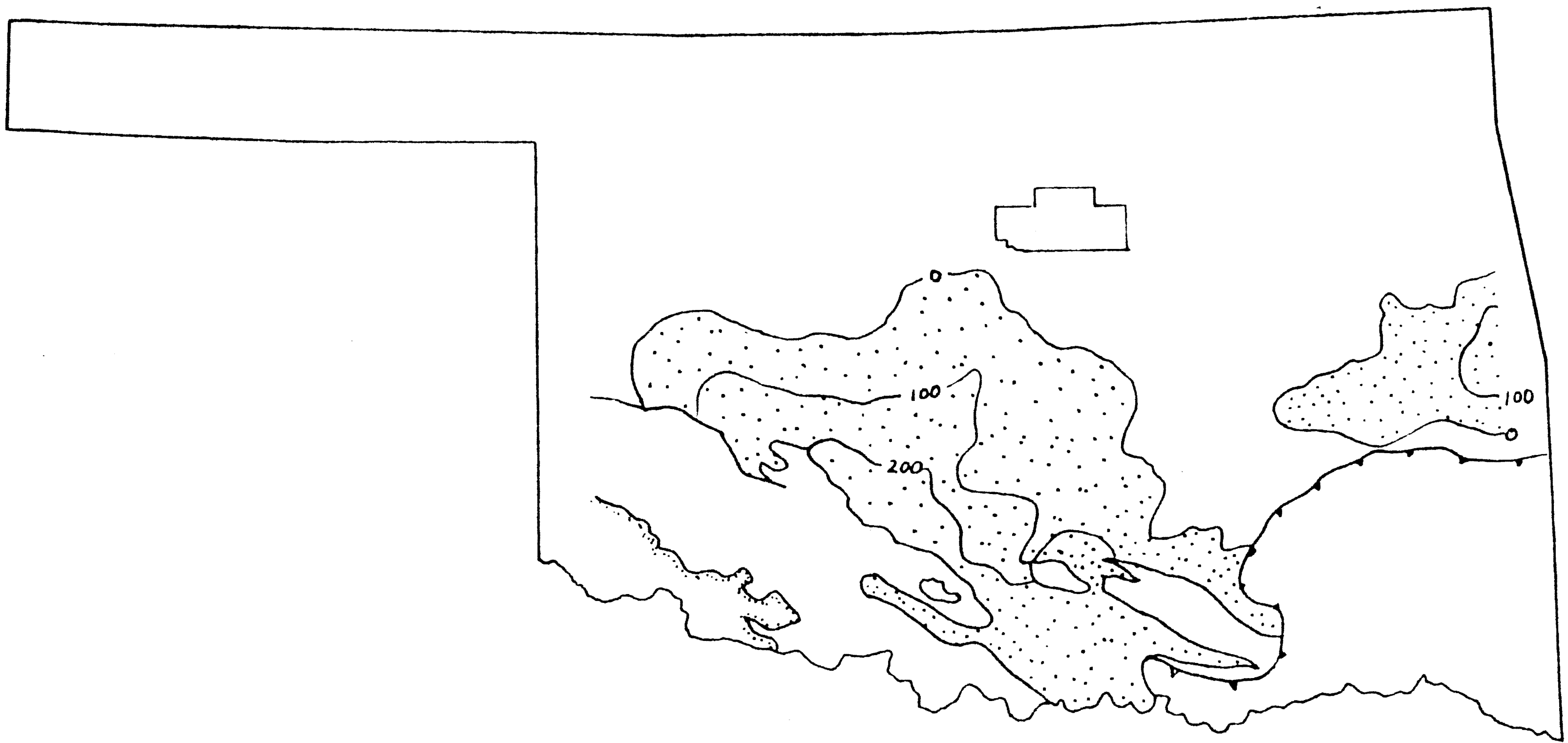



Figure 11. Isopach Map of the Joins Formation and Equivalents
(after Schramm, 1964).

are associated with red and maroon shales, many show an orange cast (Albano, 1975).

Cronenwett (1956) suggested that the coarse dolomite crystals and red shales originated in oxidizing conditions of shallow water and possibly are indicative of periods of emergence. Some samples of the shales are not entirely red or maroon but are mottled with green; the ratio of maroon to green shale increases northeastward toward the platform.

The lower sandstone unit of the Oil Creek Formation is not traceable into the study area. It is maximally 65 feet thick in the southwestern section of the state. The upper unit is as thick as 120 feet in the southwestern portion of Oklahoma. This unit is traceable in the study area, where it is 50 feet thick, on the average (Figure 12).

## McLish Formation

The McLish Formation conformably overlies the Oil Creek Formation (Figure 2). It was named by Ulrich (1928) for exposures on the McLish Ranch, near Bromide, Oklahoma. The formation is composed of a basal sandstone and an upper section of interbedded green and maroon shales, with limestones and thin sandstones. Interbeds of maroon shales become more abundant on the Northeast Oklahoma Platform (Akmal, 1950) (Figure 10).

The basal sandstone is fine-grained, compact, and very dolomitic. According to Ham (1945), it commonly is greenish

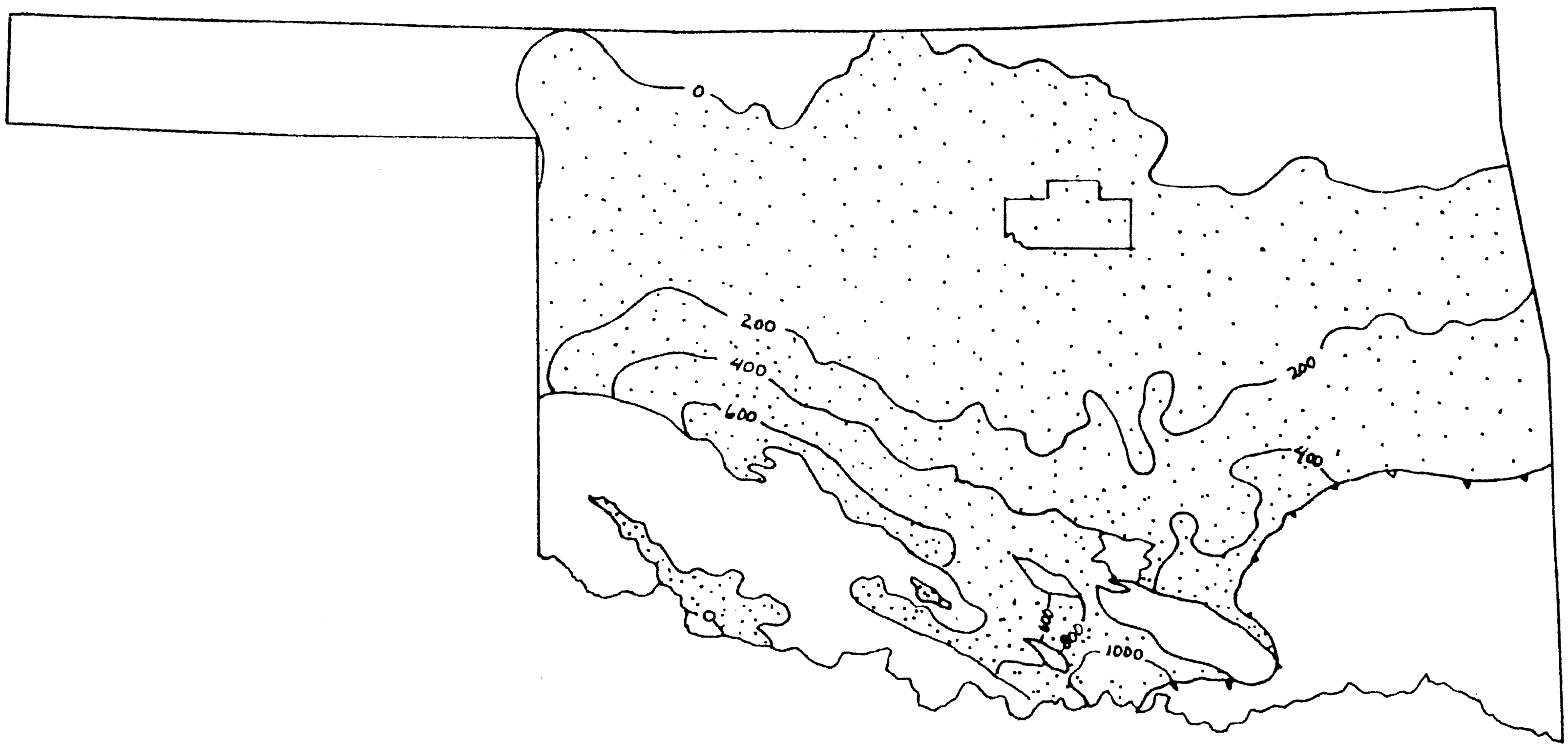



Figure 12. Isopach Map of the Oil Creek Formation and Equivalents (after Schramm, 1965).

white, the greenness being attributed to finely divided illite.

Dolomites, shales and sandstones of the upper part of the McLish are very similar to those of the upper part of the Oil Creek. One distinguishing characteristic of the McLish limestones is that they are dense and resistant to erosion, and at many places contain irregular aggregates of transparent calcite, a type of lithology termed "birdseye". In addition, coarsely crystalline aggregates of pink dolomite and of glauconite increase in abundance in the Northeast Oklahoma Platform (Figure 13).

Tulip Creek Formation

Subsurface geologists are not in agreement concerning the designation of the Tulip Creek as a separate formation (Schramm, 1964). Unless the basal sandstone of this unit is fairly thick, to distinguish this bed from similar sandstones within the McLish is difficult. In the subsurface where a "complete" section is recognizeable, the Tulip Creek Formation consists of two members: a basal sandstone, and an upper section of green shales with interbeds of red shale, thin-bedded limestones, and minor sandstones. For the purposes of this paper, the "Second Wilcox" zone will be considered to be unconformable upon the Tulip Creek Formation, as suggested by Cronenwett (1956). The Tulip Creek Formation is restricted primarily to the south and west-central part of

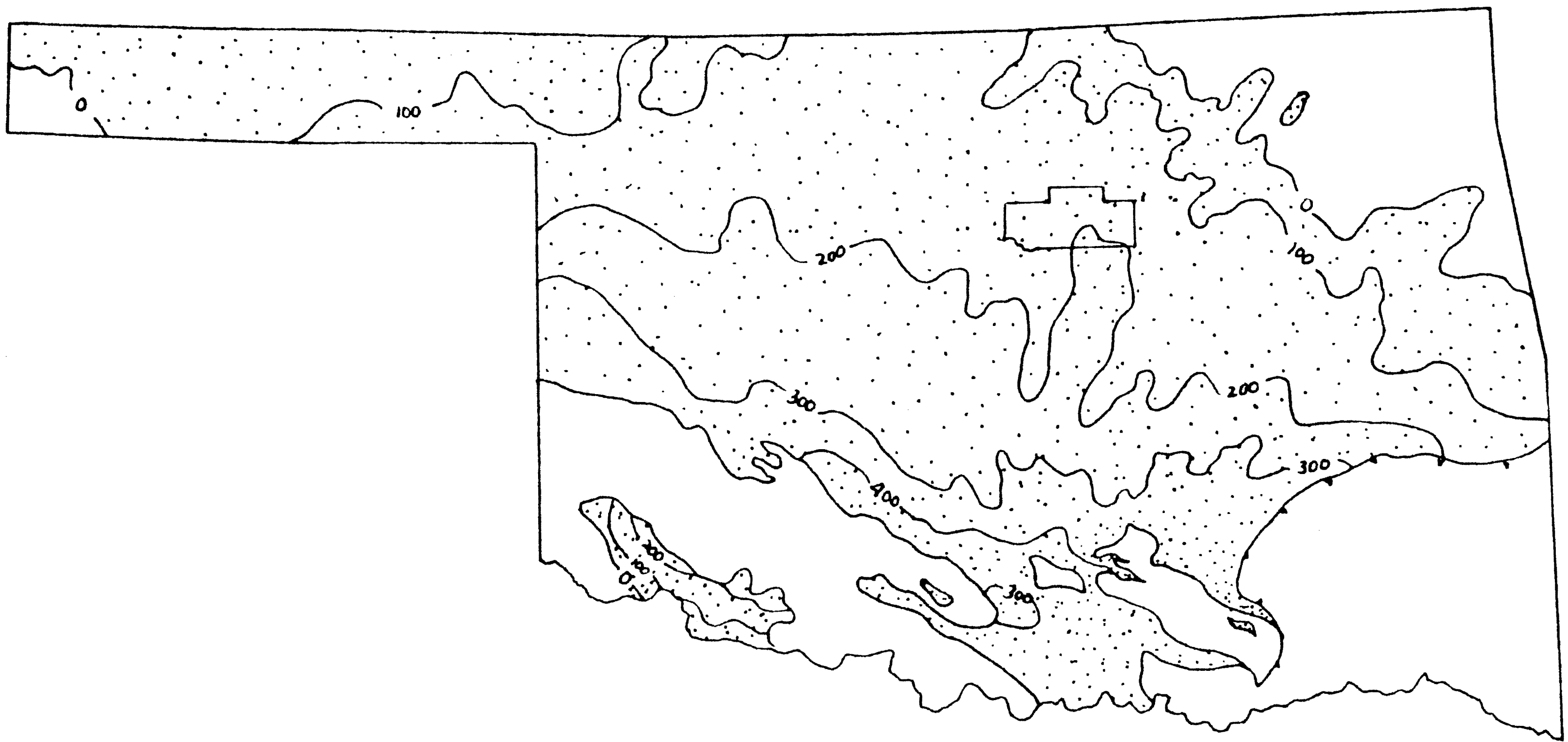



Figure 13. Isopach Map of the McLish Formation and Equivalents (after Schramm, 1965).

Oklahoma (Figure 14). The eastern limit of this formation has been truncated.

Bromide Formation:

The lower Second Wilcox unit consists primarily of white, calcareous sandstone. This basal sandstone is massive (up to 90 feet thick) and very well-sorted.

A dolomitic transitional zone overlies the lower Second Wilxoc sand. This zone is increasingly quartz-rich up-section and contains numerous fossil fragments.

The upper Wilcox unit consists of calcareous sandstone that is tan and well-sorted. Scattered dolomite rhombs are present throughout the First and Second Wilcox units (Figure 15).

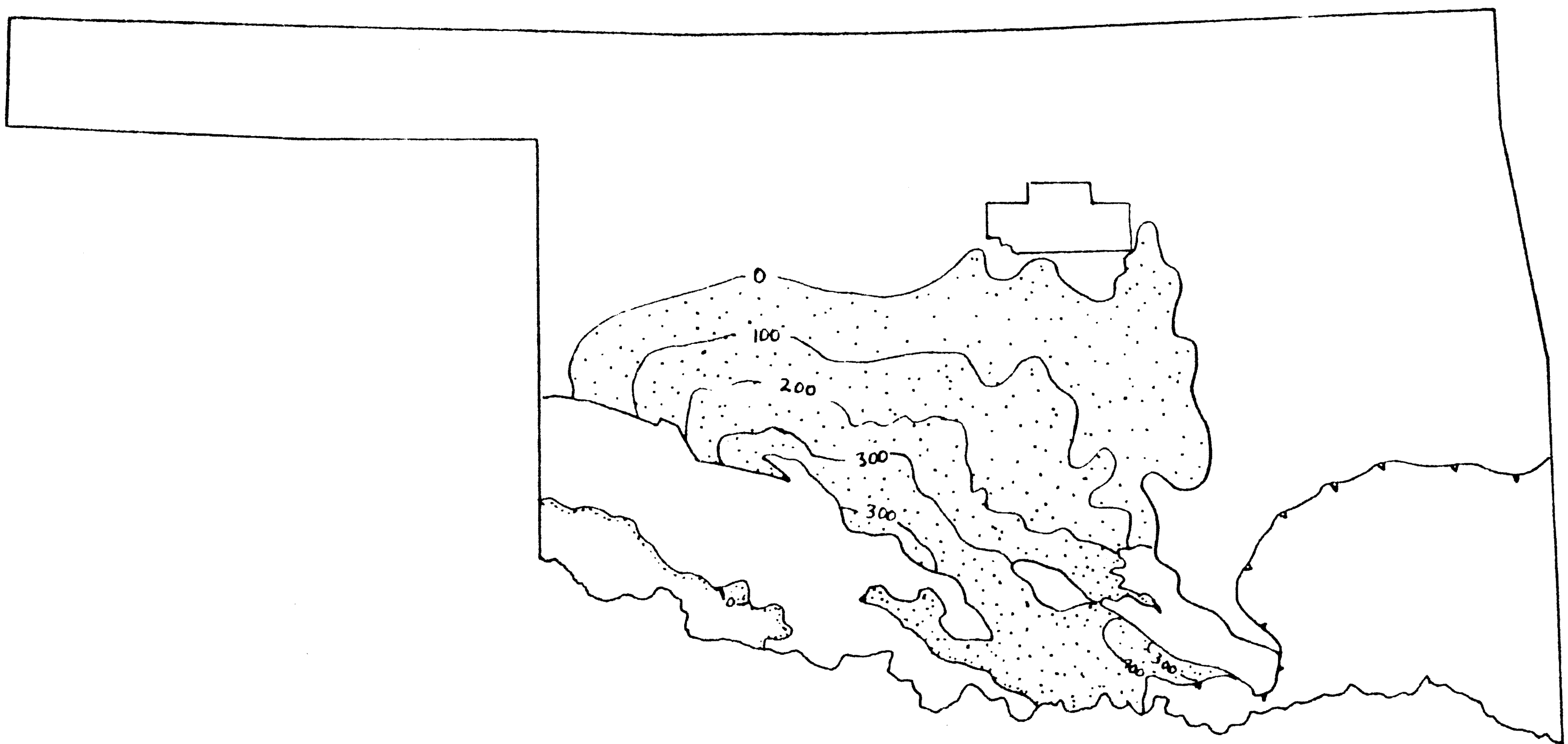



Figure 14. Isopach Map of the Tulip Creek Formation and Equivalents
(after Schramm, 1965)

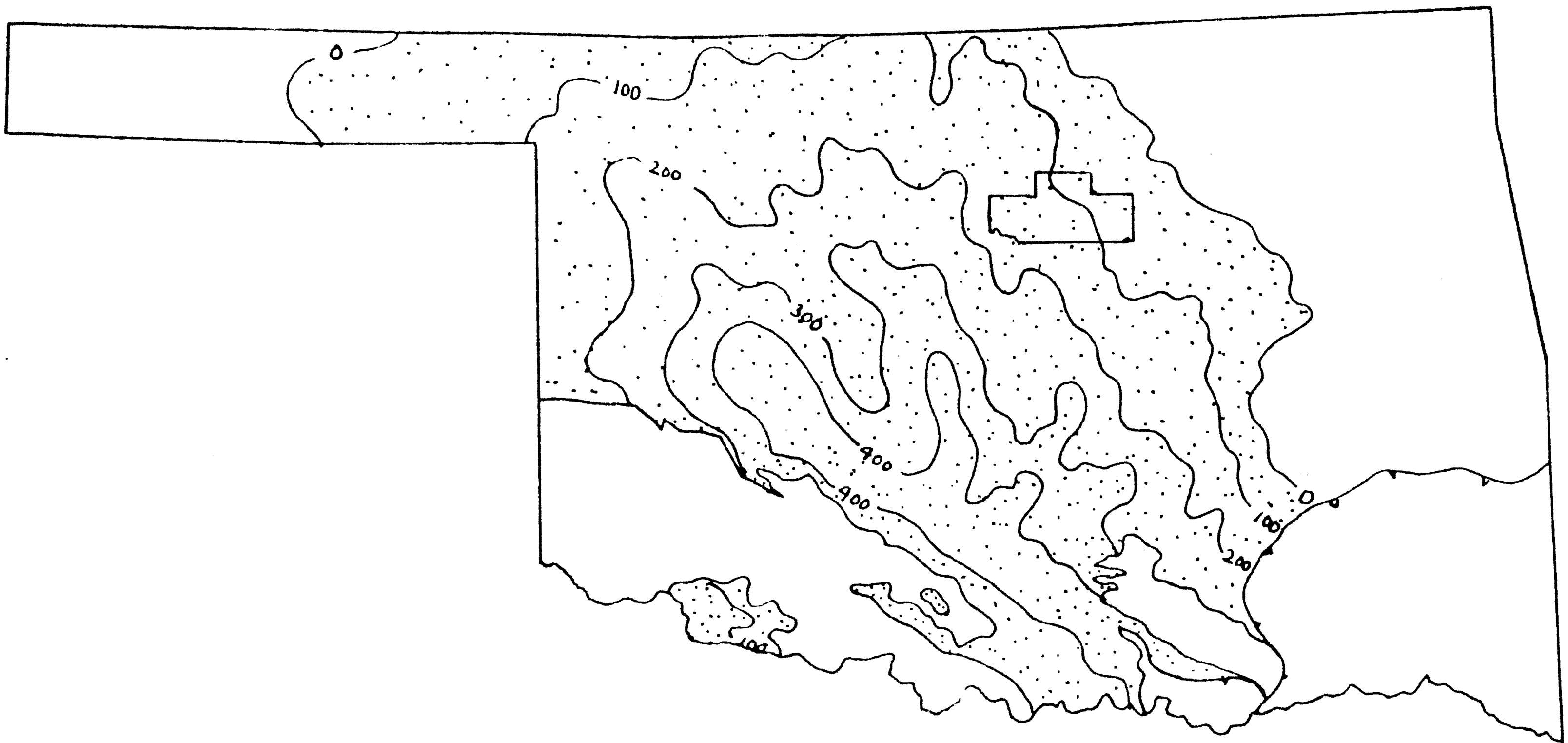



Figure 15. Isopach Map of the Bromide Formation and Equivalents (after Schramm, 1965).

# CHAPTER III

# DEPOSITIONAL ENVIRONMENT

## Introduction

According to Schramm (1964), two general tectonic aspects of the Simpson Group have been revealed by means of lithofacies and paleogeologic analysis of formations comprising the group: (1) a basin and stable shelf with pronounced structural elements, which appear to be intrinsically related to the Precambrian complex, as manifested by isopach and gross lithologic associations, and (2) interformational unconformities and post-Simpson peneplanation, suggesting tectonic episodes during and following Simpson deposition.

## Deposition of the Simpson Group

Rocks of the Middle Ordovician Simpson group record a great change in depositional environment over that of Cambro-Ordovician time (Schramm, 1964). Clean, well-sorted sand was introduced in large volume, greenish-gray shale is present in well-defined beds, and many of the limestones are either algal-mat carbonates or skeletal calcarenites (Donovon, 1986).

These carbonate rocks are rare in the Early Ordovician section. According to Ham (1978), the Chazyan Simpson units are characterized by an abrupt appearance of bryzoans and cystoids. Crinoids are in the section at their lowest stratigraphic position and brachiopods "appear" in new and much greater variety; mollusks, sponges, and trilobites persist throughout (Ham, 1978). Apparently absent from these Simpson units are the shallow-water spheroidal stromatolites of the underlying Arbuckle Group, and the deep-water graptolites that characterize the overlying Viola Limestone (Ham, 1978). Carbonate rocks of the Simpson Group mostly are algal-mat limestones and skeletal calcarenites.

In Early Black Riveran time a major pulsation of the Ozark Uplift caused widespread erosion along the Northeast Oklahoma Platform (Figure 10) (Holden, 1965). Transgression of the Simpson sea into Oklahoma and a fresh supply of sediment from the east produced a deposit similar to that of Chazyan time (Schramm, 1964). The last stages of quiescence, and deposition of carbonate sediments (Dapples, 1955). Figure 9 shows a hypothetical overview of the Midcontinent region in Late Ordovician time.

## Deposition of the "Wilcox" Sands

As previously mentioned, the Joins, Oil Creek, and McLish formations consist of sandstones, dolomites, limestones and shales in alternating beds (Figure 10). One of the distinctive features of the Tulip Creek is its erosional surface between it and the overlying Bromide. Truncation and redeposition of the sand separating these two units, as well as some of the underlying older strata, provided the erratic sands, dolomites, shales, and limestone lenses that comprise the Wilcox sands (Huffman, 1965).

Holden (1965) suggested that the Wilcox onlapped the Northeast Oklahoma Platform. Kochick (1978) also suggested an onlapping depositional environment for the study area, as shown by his outcrop map in Figure 16. According to Ireland (1965), "sheet sands" were spread over the shelf area by southwestward longshore drift from northern, intermediate, and local source areas.

Continued erosion of the Ozarkia landmass during Middle Ordovician time provided most of the clastics that were being introduced into the sea, only to be well-sorted and reworked, then deposited progressively under turbulent conditions in the encroaching sea as the Second Wilcox (Graves, 1955).

The Second Wilcox sand consists primarily of coarse, well-rounded quartz grains and associated quartzose green shale (Akmal, 1950). Frosted sand grains suggest some eolian reworking (Akmal, 1950), and tabular and trough cross-bedding in the Second Wilcox suggest that sand was deposited in an environment with a fairly high energy regime (Goilaway and Hobday, 1983).

According to Graves (1955), slight instability on the shelf during Middle Ordovician time developed as dolomites, limestones, and shales of the Marshall zone were being

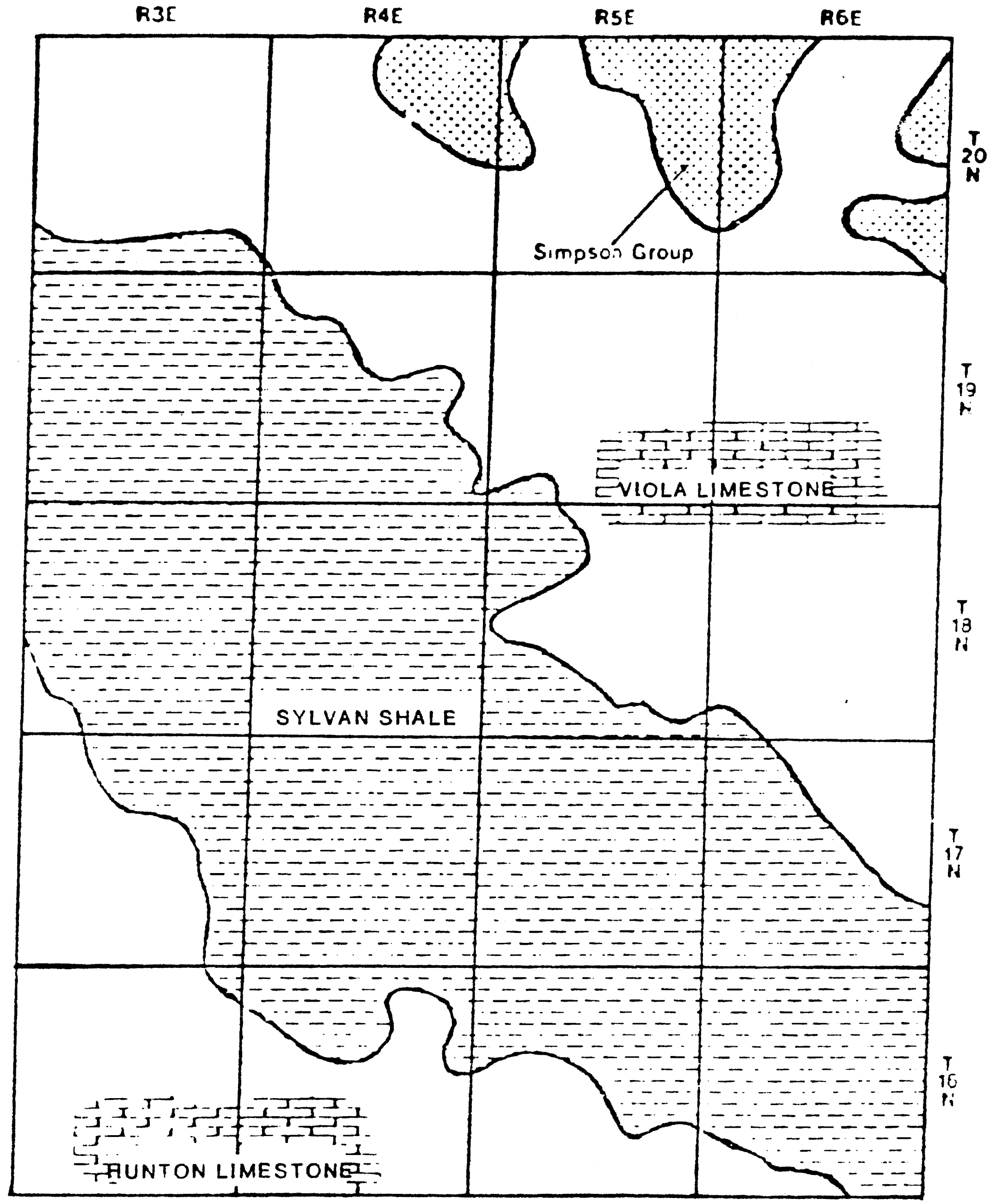



Figure 16. General Outcrop Patterns of Stratigraphic Units Beneath the Woodford Shale (after Kochick, 1978).

deposited. This stratigraphic unit (Figure 2) is considered to be evidence of transition during the deposition of the Wilcox units (Akmal, 1950). The Marshall zone consists of dolomitic shale, silicified fossils and chert fragments, oolitic dolomite, and dolomite in ascending order.

Generally, the First Wilcox is thinner than the Second Wilcox. The First Wilcox is porous quartzarenite consisting of a mixture of rounded, polished grains and rounded, frosted grains (Akmal, 1950). According to Shelton, Ross, Garden and Franks, (1985), the reservoir quality of the First Wilcox may be impaired locally by clay and carbonate cement. Laminated bedding and tabular and trough crossbedding are also evident in the First Wilcox.

The First and Second Wilcox both show types of evidence that are suggestive of deposition within an environment of fairly high energy. According to Galloway and Hobday (1983), nearshore shallowing is accompanied by an increase in physical energy and a decrease in biological manifestations. Simply stated, the energy level was higher during deposition of the First and Second Wilcox than during deposition of the Marshall zone. Furthermore, algae, ooids, and lime mud throughout the Marshall zone, along with clean sands of the Wilcox, suggest that this entire sequence was deposited under shallow marine conditions (Al-Shaieb, personal communication, 1987). Elliott (1986) suggested that numerous transgressive-regressive couplets typically are recorded at shallow marine shorefaces that are acted upon by sea-level oscillations. During Middle

Ordovician time, the prevalent environment on the Northeast Oklahoma Platform possibly was similar to Elliott's model.

## Descriptions of Cores

Five cores of the Wilcox were described and sampled. Plate I shows locations of the cores. Petrologic logs of the cores are in Appendix A. The cores were examined for general lithology, constituents, sedimentary structures, and grain sizes, in order to gain insight on environments of deposition.

Well No. 1: Southport Exploration, Inc., Myers 1-21, SW NW SW, Section 21, T.19 N., R.3 E. The cored interval is from 4365 to 4410 feet, which is throughout the entire Wilcox section (Figure 17) (Appendix A, Log 1). The core consists of an upper calcareous sandstone, a middle sandy dolomite zone, and a lower sandstone. Sandstones are moderately sorted to well-sorted, gray and white, and medium-grained. Sedimentary features include abundant shale wisps, bioturbated and burrowed beds, and ripple laminae. Hard grounds and stylolites are also evident in the middle dolomite zone. According to core analysis data compiled by Rotary Engineers Laboratories, porosity ranges from less than 1 percent to about 15 percent and saturation with respect to oil ranges from 0 to 42 percent.

Well No. 2: Southport Exploration, Inc., Keys 2-22, E 1/2 NW NW, Section 22, T.19 N., R.3 E. The cored interval is from 4386 to 4413 feet (Appendix A, Log 2). Figure 18 shows a

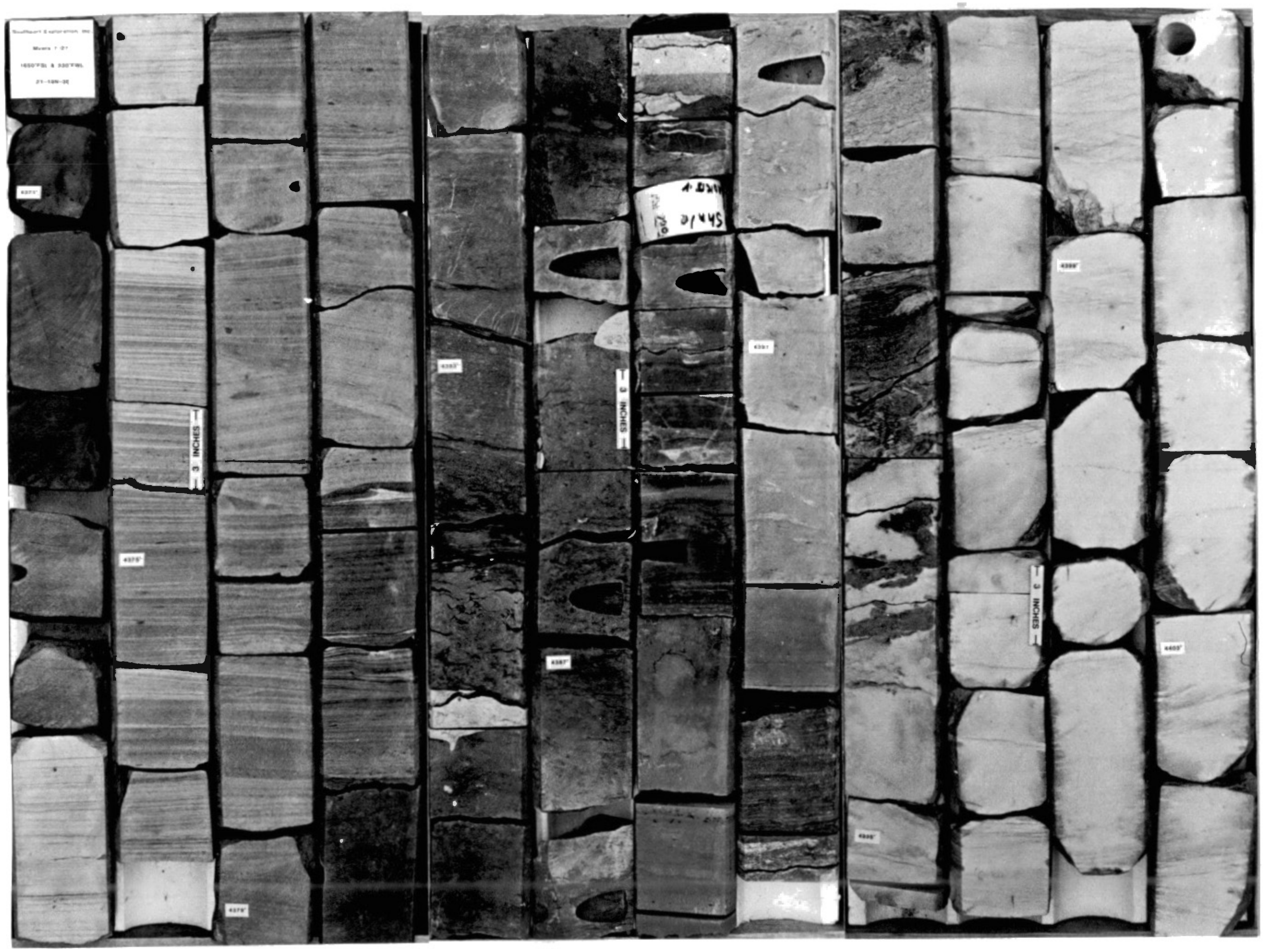


Figure 17. Photograph of Core, Southport Expl., Inc., Myers 1-21, Section 21, T.19 M., R.3 E

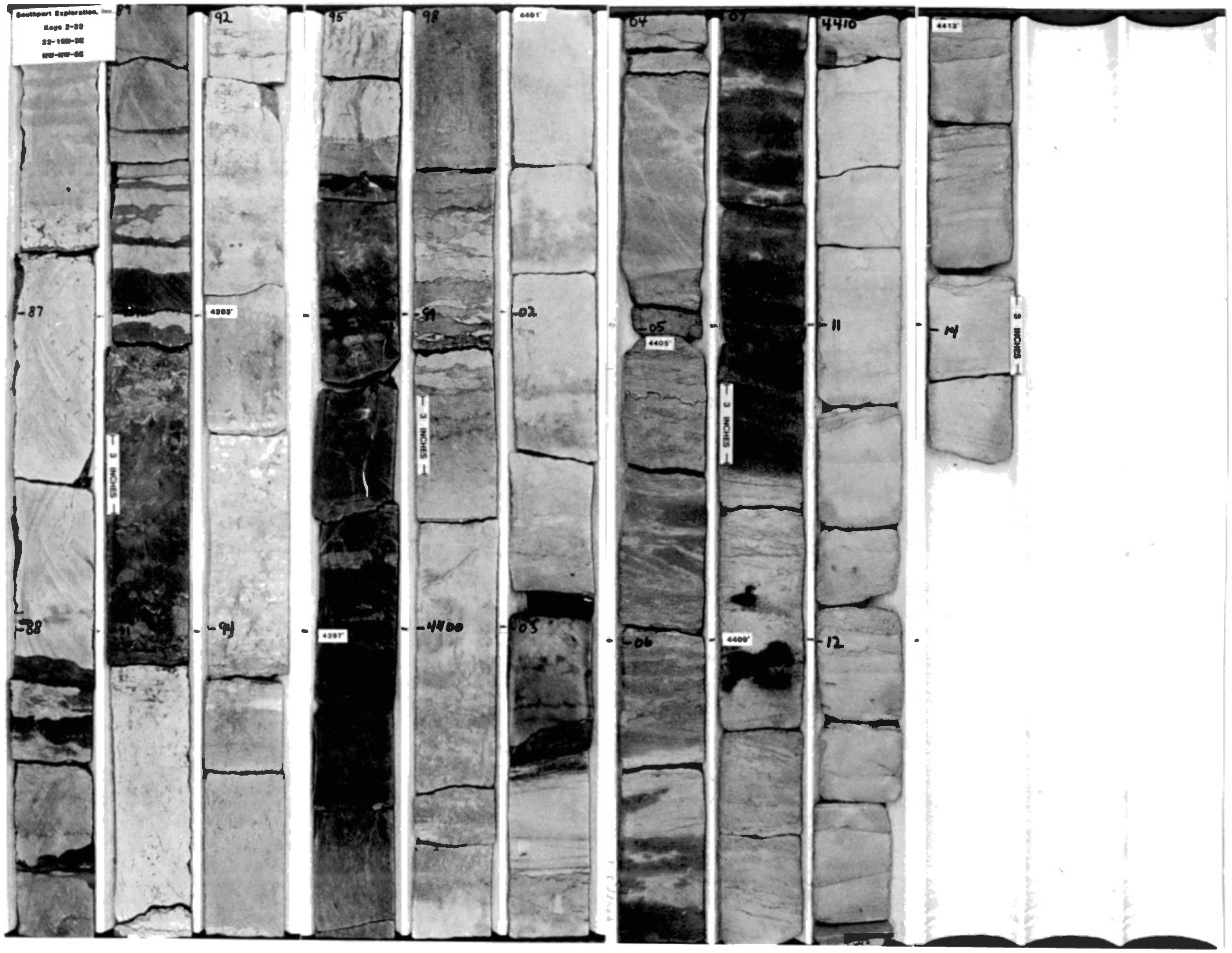


Figure 18. Photograph of Core, Southport Expl., Inc.,
Keys 22, Section 22, T.19 N., R.3 E

photograph of the cored interval. The upper dolomitic facies corresponds to the Marshall zone; it is composed of intercalated stylolites and gray and black shales. Shell fragments are concentrated in thin zones along with carbonaceous nodules and bioturbated rock. The underlying sandstone consists of mottled green sand containing a small number of rip-up clasts. The sand is moderately to poorly sorted and has splotchy stains of oil. The Second Wilcox below the mottled sand is well-sorted, white, and shows tabular and trough cross-stratification.

Well No. 3: Southport Exploration, Inc., Keys 1-22, SW SW NW, Section 22, T.19 N., R.3 E. The cored interval is from 4413 to 4444 feet (Appendix A, Log 3). The core consists of an upper sandy dolomite unit, a middle sandstone, and a lower dolomite (Figure 19). The sandstone corresponds to the First Wilcox. It is gray-green to black, moderately sorted to well-sorted, fine- to medium-grained, and stained slightly by oil. The most prominent feature of this sandstone is that the upper 7 feet contain "dead oil" and closely resemble tar sand. Sedimentary features include shale wisps, tabular and ripple cross-bedding, and a small amount of bioturbated rock. Hard-grounds and stylolites are also visible. The porosity ranges from 3 to 22 percent and oil saturation ranges from 0 to 48 percent (Rotary Engineers Laboratories, 1986). This well is the only one studied that is currently producing oil.

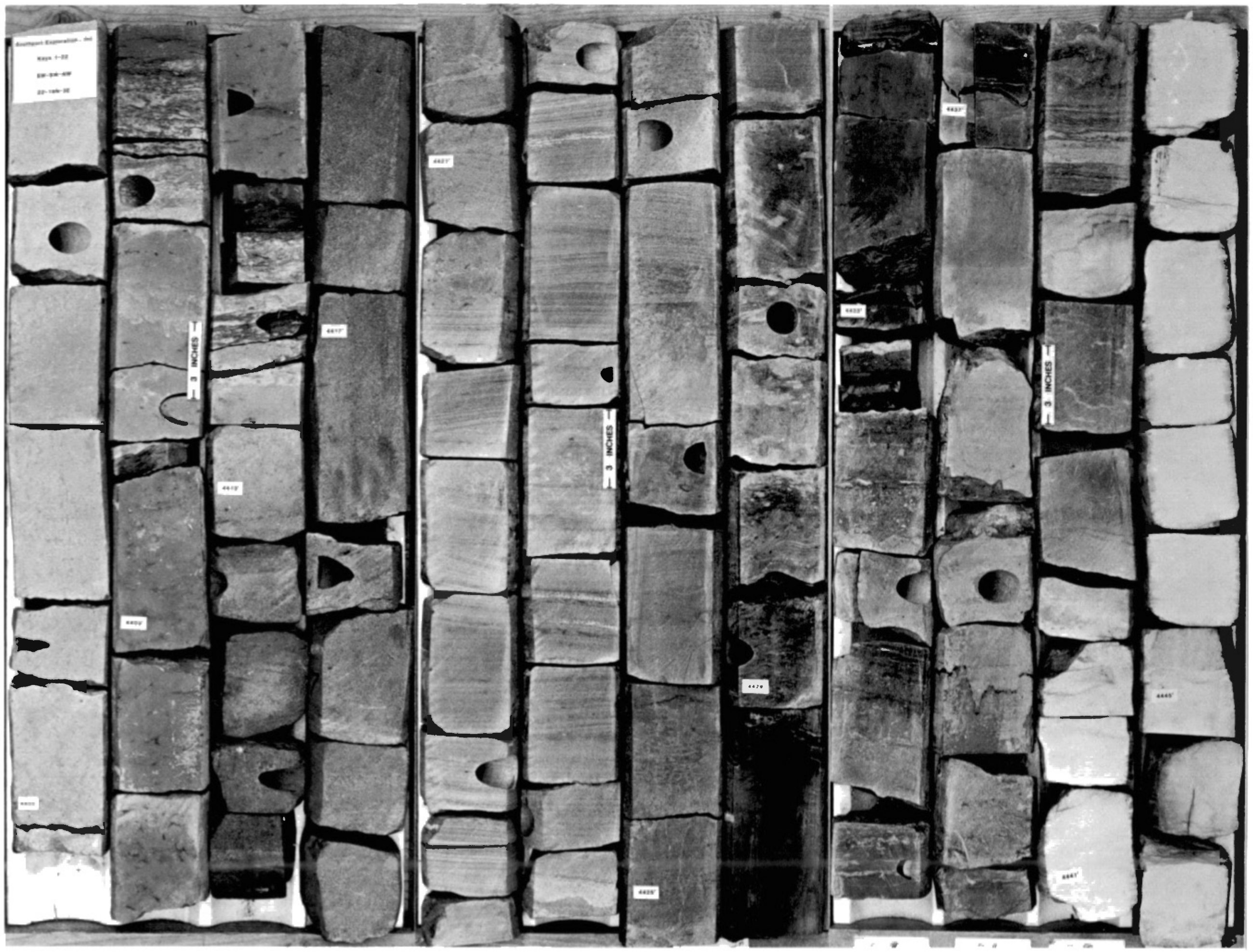



Figure 19. Photograph of Core, Southport Expl., Inc., Keys 1-22, Section 22, T.19 N., R.3 E.

Well No. 4: Southport Exploration, Inc., Palovik 1-20, SE NE SE, Section 20, T.19 N., R.3 E. The cored interval is from 4365 feet to 4386 feet (Appendix A, Log 4). This interval (Figure 20) includes the Marshall zone facies and the Second Wilcox. The upper core is dolomite with stylolites and shale. Sandy shale overlain by oil-stained sandstone underlie the Marshall zone. The lowermost white sandstone of the Second Wilcox is bioturbated in places and contains some wisps of shale. It is well-sorted, medium-grained, and contains tabular and trough cross-stratification.

Well No. 5: Southport Exploration, Inc., Arrington 1-28, NW NW NW, Section 28, T.19 N., R.3 E. The cored interval is from 4403 to 4420 feet (Appendix A, Log 5). The core consists of an upper dolomite with numerous stylolites and a lower sandstone (Figure 21). The dolomite is considered to be the lower part of the Viola Limestone, and the sandstone is the First Wilcox. The sand is moderately sorted, fine- to medium grained, gray and white, and well-cemented. Sedimentary features include slightly bioturbated rock, stylolites, and ripple cross-stratification. Porosity of the sand ranges from 3 to 15 percent, and oil saturation ranges from 0 to 13 percent (Rotary Engineers Laboratories, 1986).

## Stratigraphic Cross-sections

Two stratigraphic cross-sections (Plates II and III) show the lateral facies relationships of the First Wilcox and overlying units. A North-South (strike) and an East-West

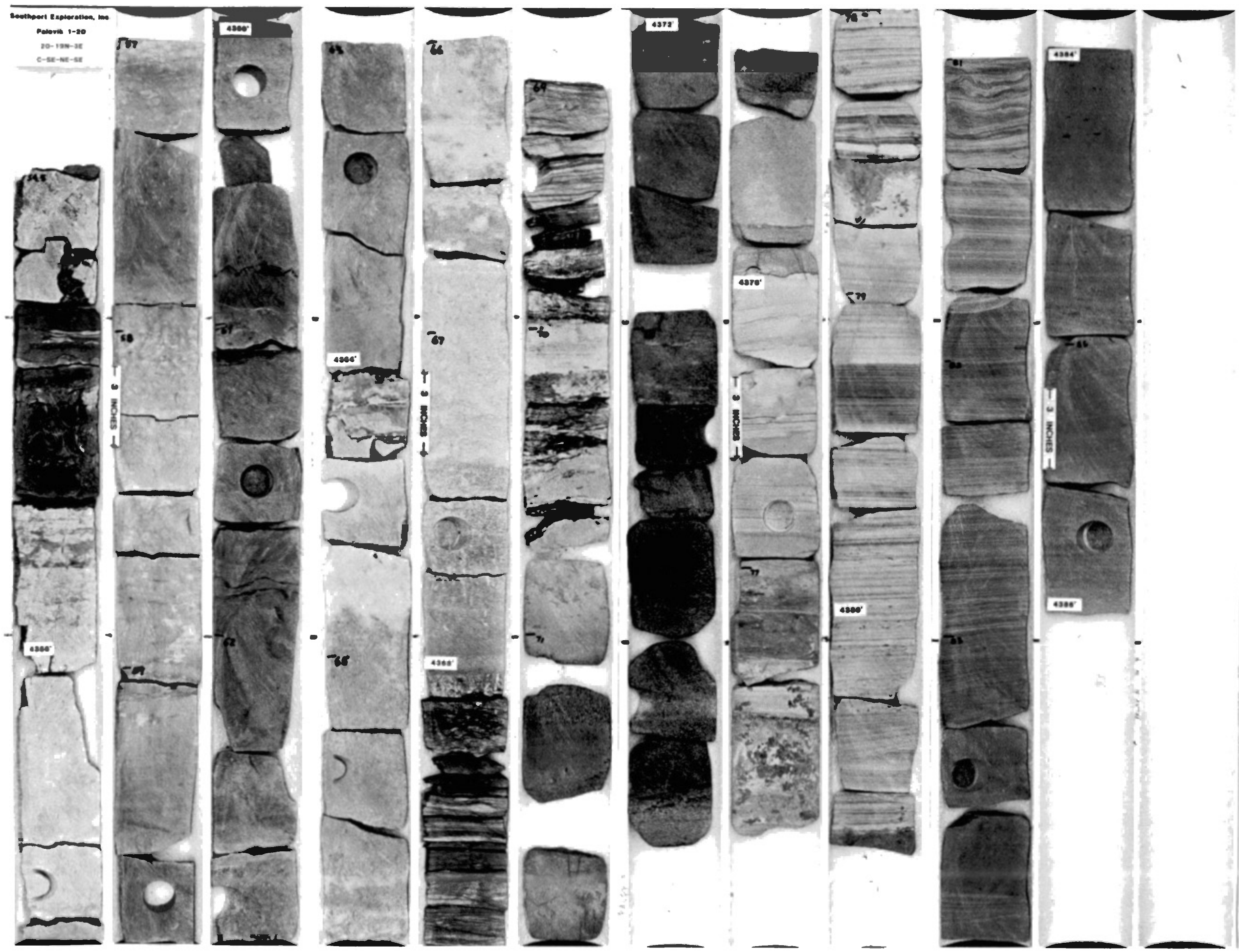



Figure 20. Photograph of Core, Southport Expl., Inc.,
Palovik 1-20, Section 20, T.19 N., R.3 E.


Figure 21. Photograph of Core, Southport Expl., Inc., Arrington 1-28, Section 28, T.19 N., R.3 E

(dip) cross-section utilized two of the cores that were studied. Figure 22 shows a "type" electric log of Middle Ordovician through Lower Mississippian strata. Datum of the stratigraphic cross-sections was the base of the Woodford Shale. The Woodford is conformable upon the Misener Sand and unconformable upon the Hunton (Cronenwett, 1955). The Woodford Shale overlapped all the previously deposited formations in northeastern Oklahoma and is a persistent and extensive stratigraphic time-marker throughout the Northern Platform (Cronenwett, 1955).

In both cross-sections, the Viola Limestone lithologic time-marker is subparallel to the base of the Woodford Shale (Plates II and III). Similar to the entire section, the Viola exhibits a westerly dip. Distribution of the Misener is erratic, suggesting influence of paleotopography. As shown by its "boxy" spontaneous-potential curve, much of the Misener may be channel-fill deposits.

The Sylvan Shale shows pronounced evidence of westward thickening. The East-West cross-section (Plate III) shows evidence of a positive correlation between the structurally-higher Wilcox wells and thinner sections of Sylvan Shale. This would suggest that the paleotopography was slightly irregular when the Sylvan was deposited.

As mentioned earlier, the Viola is subparallel to the base of the Woodford throughout the study area. Similarly, the First Wilcox is subparallel to the base of the Woodford. The First Wilcox thickens to the west-southwest, but is of

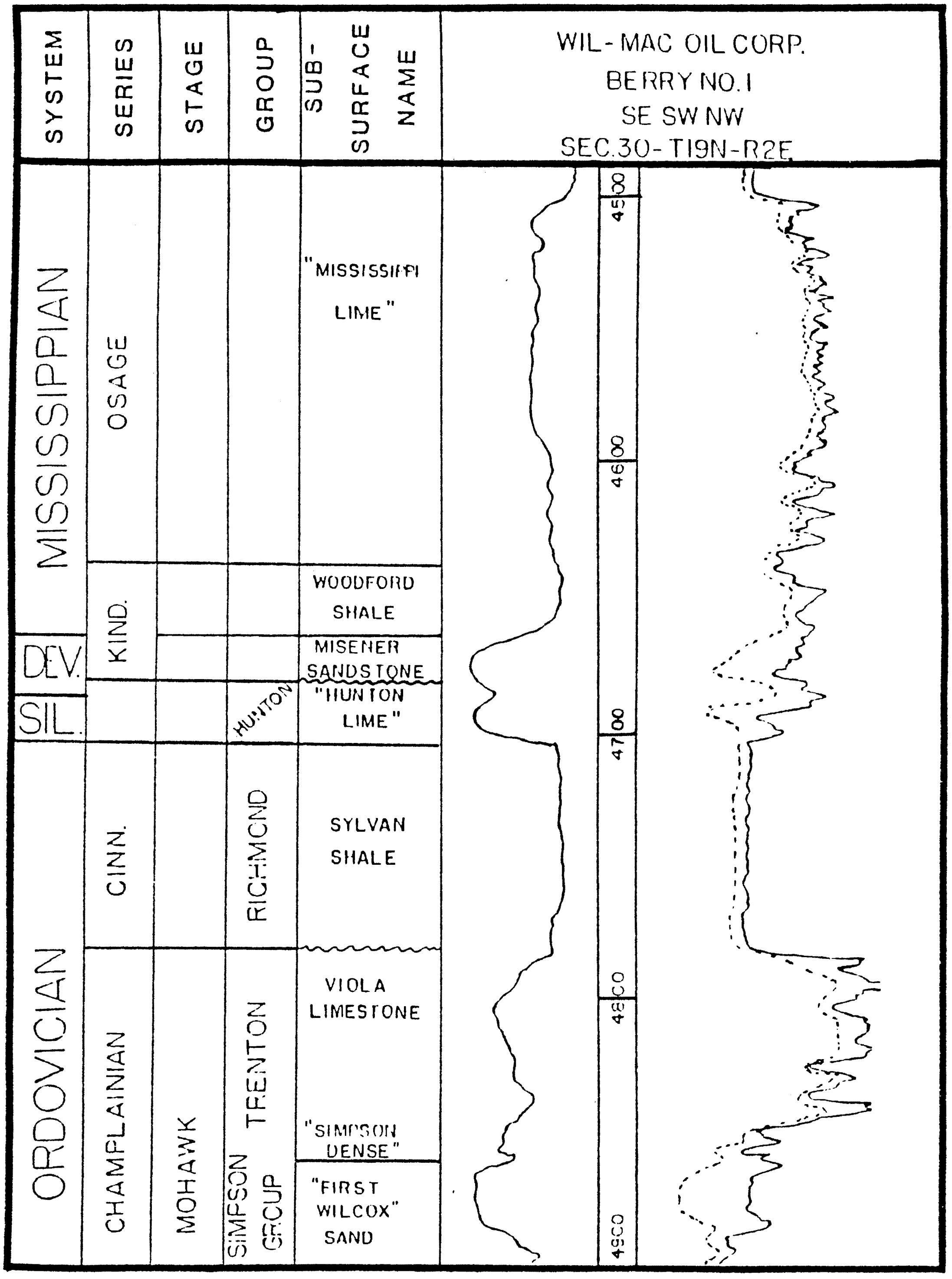



Figure 22. "Type" Log for Middle Ordovician Through Mississippian Strata in Area of Study.

fairly "uniform" thickness throughout both cross-sections (Plates II and III). According to Cronenwett (1955), the "uniformity" of the First Wilcox is due to deposition under essentially stable conditions in a neritic environment.

## Maps

Three structural contour maps were constructed, including maps of the top of the Mississippi Lime, top of the Viola Limestone, and top of the First Wilcox Sand (Plates IV, V and VI). All three maps exhibit similar features: regional strike is north-northwest, dip is west-southwest except where altered locally by folds or faults, and major faults have northerly trends.

Dip varies from about 50 to about 75 feet per mile throughout most of the area. Numerous westward-plunging anticlinal noses are important in the entrapment of hydrocarbons, a relationship discussed elsewhere in this thesis. A secondary trend toward the southwest is also evident in the trends of some anticlinal noses. Two major northerly-trending fault zones flank the study area. One extends from section 32, T.19 N., R.2 E., to section 10, T.20 N., R.2 E. The other major fault zone extends from section 34, T.19 N., R.4 E., to section 3, T.19 N., R.4 E. (Plates IV, V, and VI).

Structurally, there are no major changes between the Mississippi strata and the Viola and First Wilcox, except for minor faulting. The similarity of structural fabric in shallow and deep strata suggests that the structural geology of the study area originated in basement rock and has been translated through the Paleozoic section by intermittent movement.

The isolith and one isopachous maps show geometry of the Sylvan Shale, First Wilcox Sand, and the combined Misener, Hunton, and Sylvan section (Plates VII, VIII and IX). The Sylvan Shale isolith revealed general west-southwestward thickening, punctuated by definite thinning along the major northerly-trending fault zones located on the east and west sides of the study area (Plate VII). The Sylvan Shale is absent from most of T.20 N., R.4 E., and from the north-eastern part of T.20 N., R.3 E. Following the same northeasterly trend, the Sylvan also thins markedly in the center of the study area.

The isopachous map of the Misener-Sylvan section reveals westerly thickening, similar to that of the Sylvan (Plate IX). Unlike the Sylvan isolith, this map shows a lenticular pattern of thickening and thinning instead of the "finger-like" distribution of the Sylvan Shale (Plate VII). The Misener-Sylvan section is absent from the northeastern part of T.20 N., R.4 E.

The First Wilcox isolith does not reveal the true geometry of this unit because data in the study area are sparse (Plate VIII). Southwesterly thickening is apparent, but further conclusions drawn from this map would be entirely conjectural.

# CHAPTER IV

# PETROLOGY

## Introduction

Objectives of this chapter are to discuss methodology of dealing with petrology of the rocks under study, and to describe the detrital and authigenic constituents of the Wilcox Sandstone.

## Methodology

Several methods were used to determine mineralogy of detrital and authigenic constituents in the Wilcox sands, including thin-section petrography, clay extraction for removal of organic, iron-oxide, and carbonate coatings (Kittrick and Hope, 1963) and x-ray diffraction of natural and "clay extracted" powdered samples.

Thin-section petrography was used for quantitative mineralogic determination. X-ray diffraction of powdered samples and x-ray diffraction of clay-extracted samples were used to determine gross mineralogy and to determine specific clay constituents.

## Detrital Constituents

Thin sections from five cores were examined for quantitative mineralogy (Plate I). Wilcox samples analyzed in this research primarily are quartzarenites. In all samples, grain size varies from fine to coarse, but predominantly the sand is medium-grained (Figure 23).

Quartz ranges from 71 to 80 percent and averages 75 percent of the total constituents. In thin section, quartz clearly is monocrystalline and exhibits small amounts of undulose extinction, polycrystalline quartz is present in trace amounts.

Feldspars are scarce, averaging .5 percent in a small number of thin sections. A few fragments of microcline feldspar were observed, as well as trace amounts of orthoclase. Tourmaline, an accessory heavy mineral, occurs in trace amounts in some of the samples (Figure 24). It is characterized by hexagonal crystal shape, high relief and pleochroism in various colors including brown, green, and purple. Glauconite is present in trace amounts and characteristically is non-pleochroic and bright green.

Fragments of brachiopods, trilobites, echinoderms and ostracods are present in small amounts (Figure 25). Sparse constituents include algae, oolites and fragments of bryzoa (Figure 26), as well as rock fragments that appear to be rip-up clasts.

Figure 23. Photomicrograph of Quartz Grains (x100 ppl).

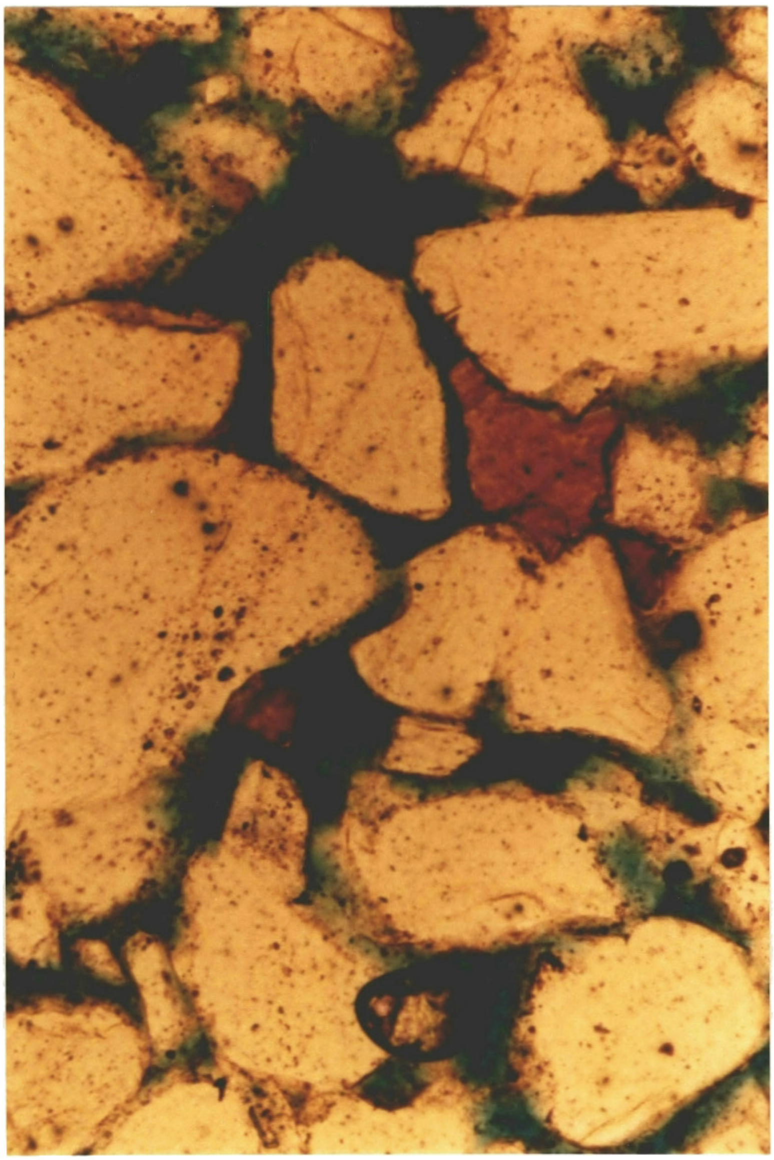


Figure 24. Photomicrograph of Detrital Tourmaline (x100 ppl).

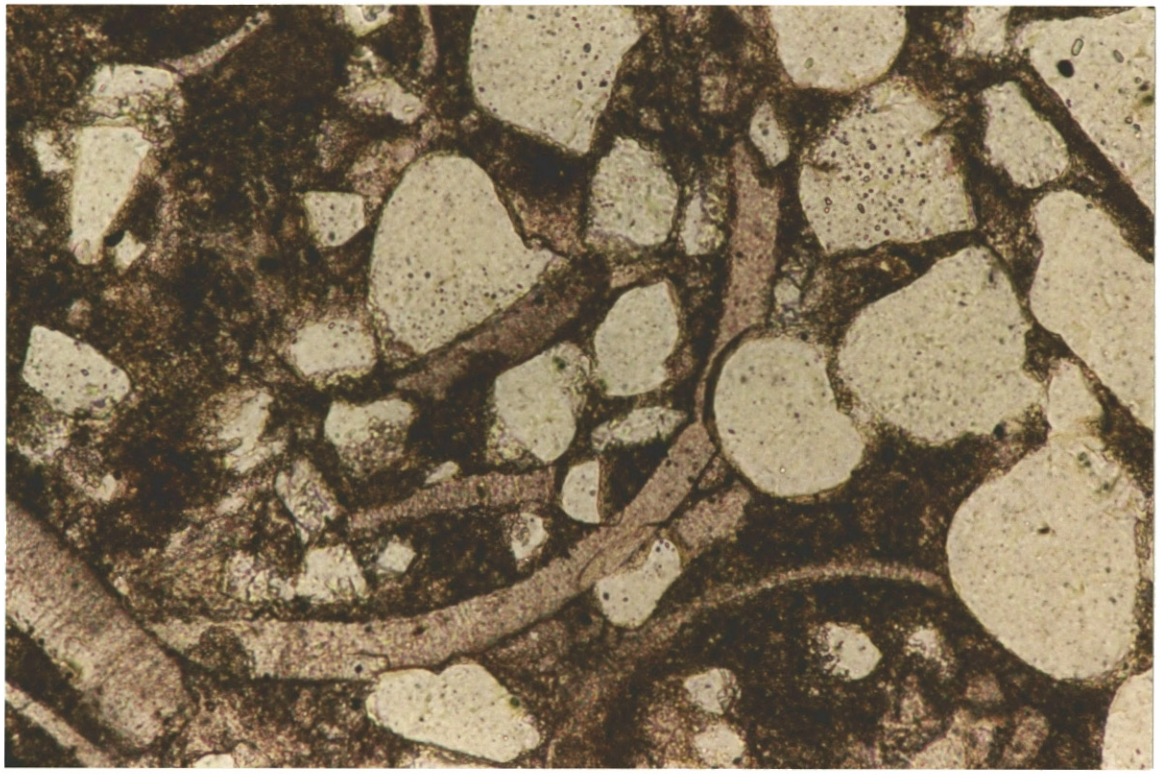


Figure 25. Photomicrograph of Brachiopod, Trilobite and Ostracod Fragments (x100 ppl).

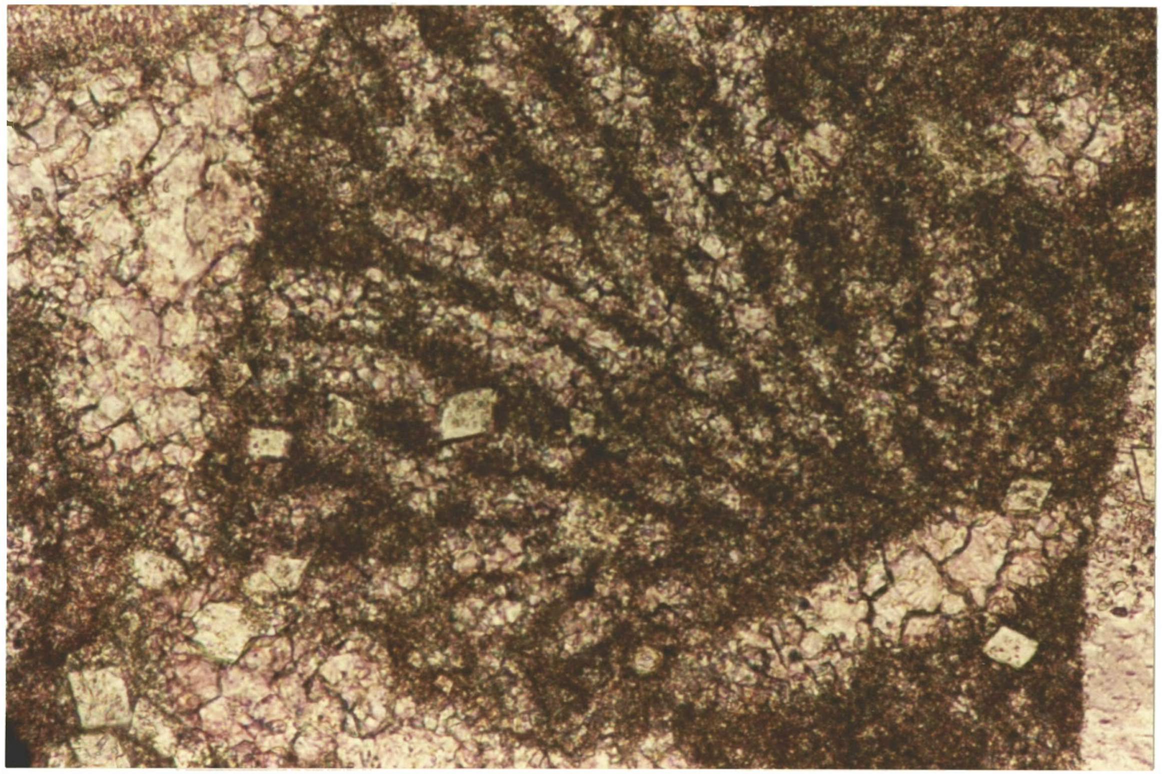


Figure 26. Photomicrograph of Algae Fragments (x100 ppl).

## Authigenic Constituents

Authigenic constituents average 12 to 16 percent in the Wilcox sands. Nine to 13 percent of the rock consists of authigenic cements, including silica, dolomite, and calcite, whereas authigenic clays (kaolinite, illite, and chlorite) make up 1 to 4 percent of the rock. One to 2 percent of the rock is pyrite.

## Authigenic Cements

Dolomitic and calcitic cement fill pore space and replace quartz grains (Figure 27). Carbonate cement ranges from zero to 7 percent and averages 3 percent of the rock. Dolomite is the more abundant carbonate cement; it has replaced calcite cement in some places (Figure 28). In addition to having replaced calcite cement, dolomite replaced quartz grains, as shown by the etched rims of the quartz in Figure 29.

Authigenic quartz, ranging from 5 to 8 percent of the rock, is present as secondary overgrowths precipitated in optical continuity with detrital quartz grains (Figures 30 and 31). Figure 32 shows a comparison of grain size and silica overgrowths.

Dissolution of silica may be enhanced by the following mechanisms (Al-Shaieb and Shelton, 1981): (1) increase in pH of the solution as a result of consumption of hydrogen ions during dissolution of feldspars, (2) shift in reaction of silica and water to favor dissolution of quartz, as a

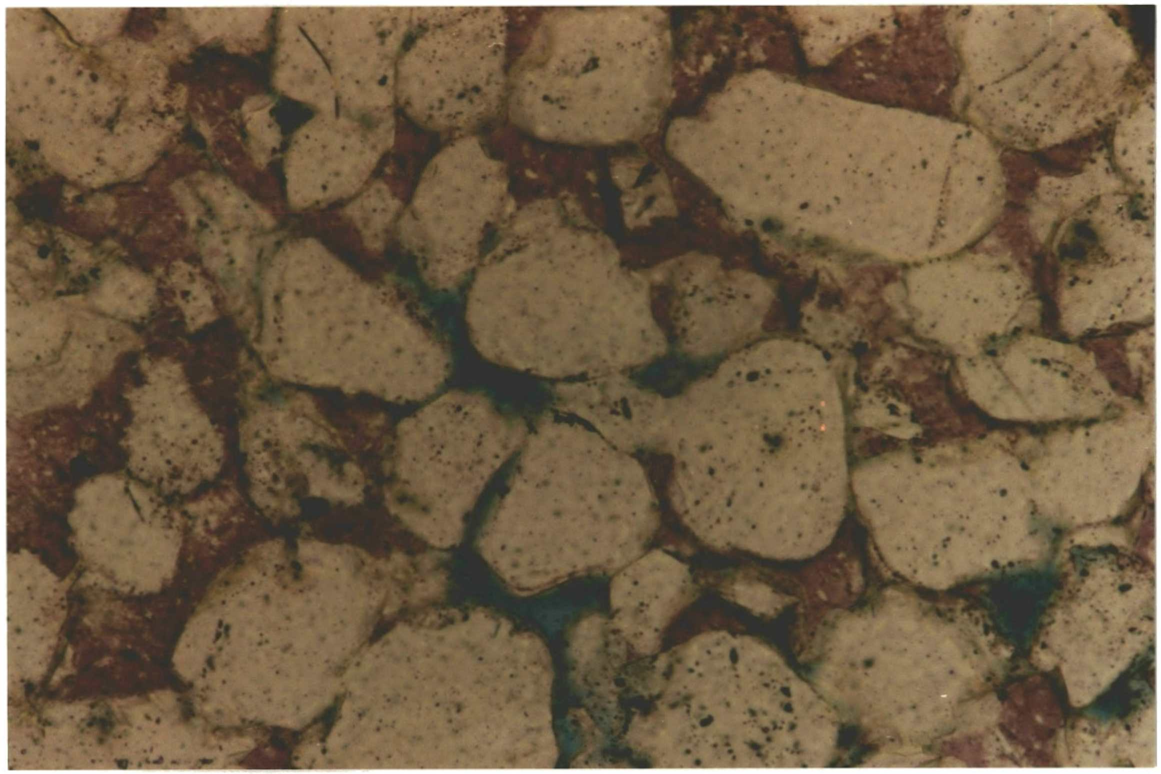


Figure 27. Photomicrograph Showing Dolomite and Calcite Cement Filling Pore Space (x100 ppl).

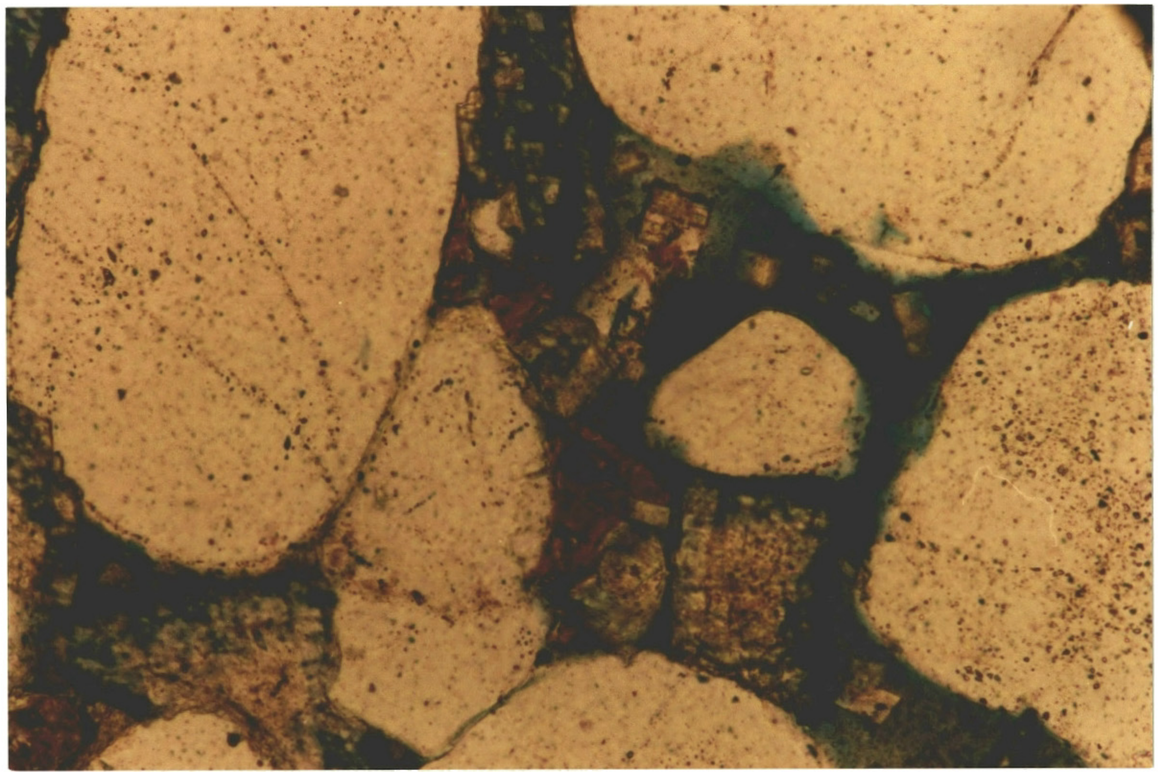


Figure 28. Photomicrograph Showing Dolomite Replacing Calcite Cement.

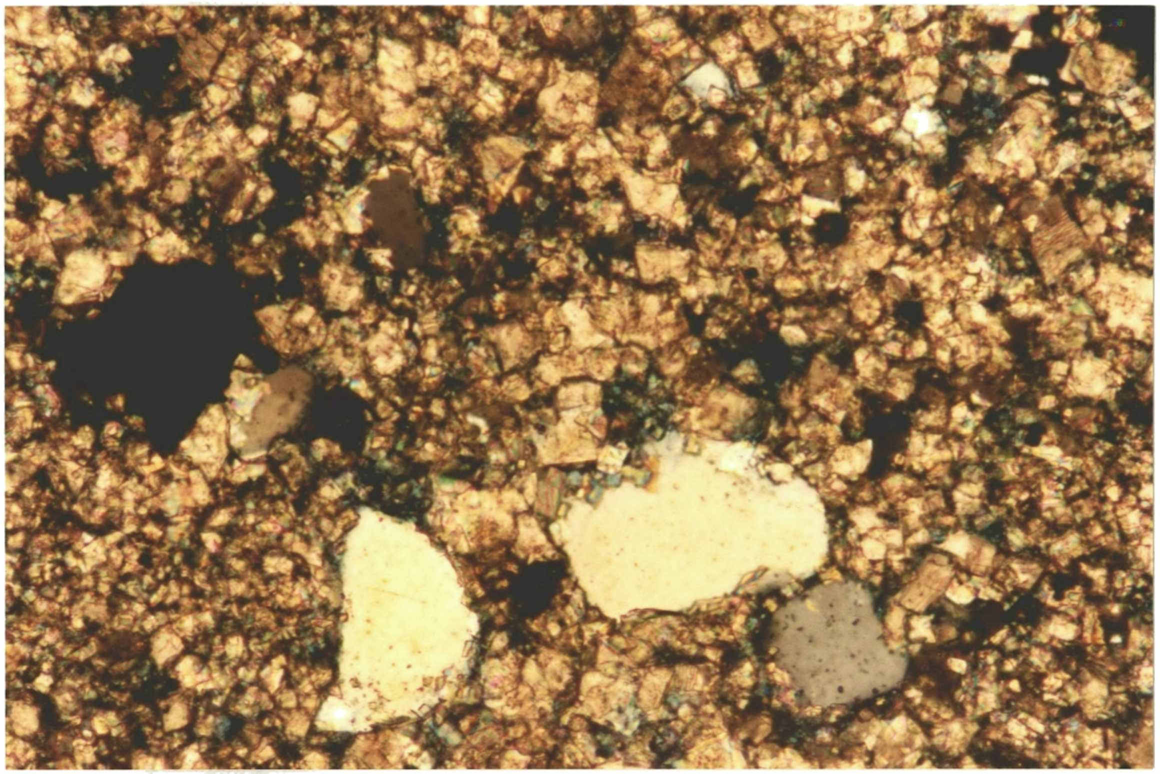


Figure 29. Photomicrograph Showing Dolomite Replacing Quartz Grains (x100 xn).

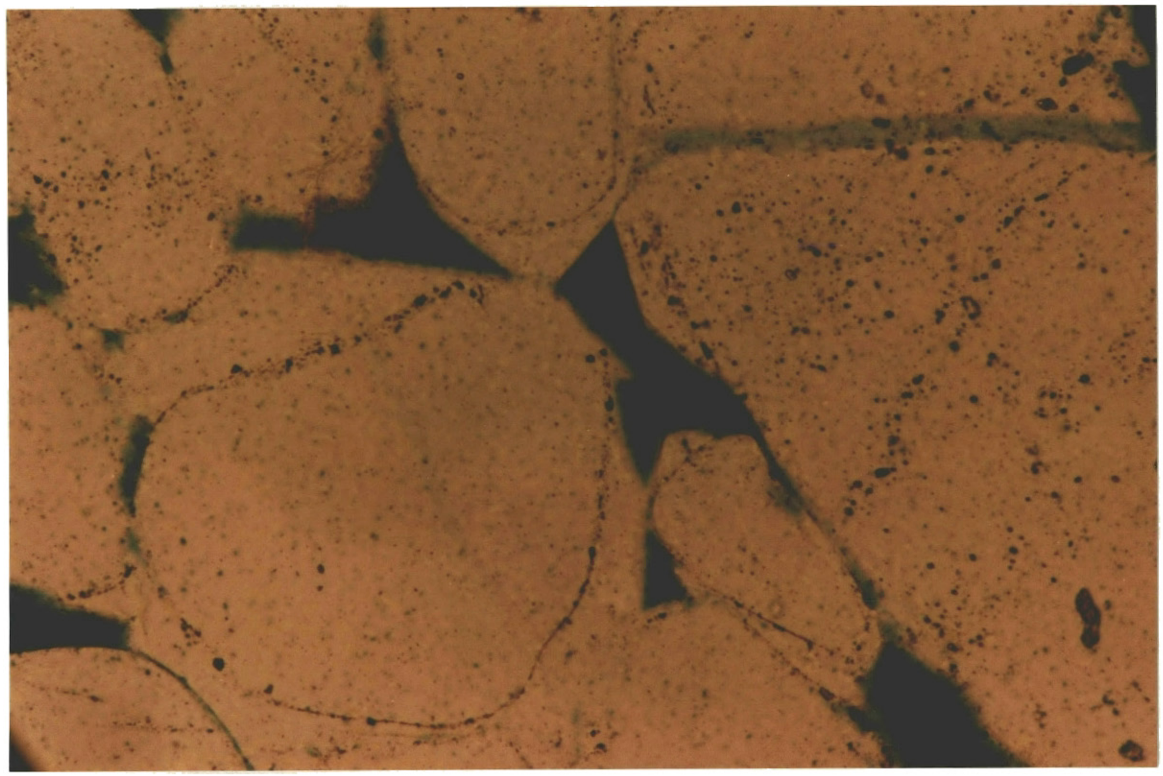


Figure 30. Photomicrograph of Syntaxial Quartz Overgrowths (x100 ppl).

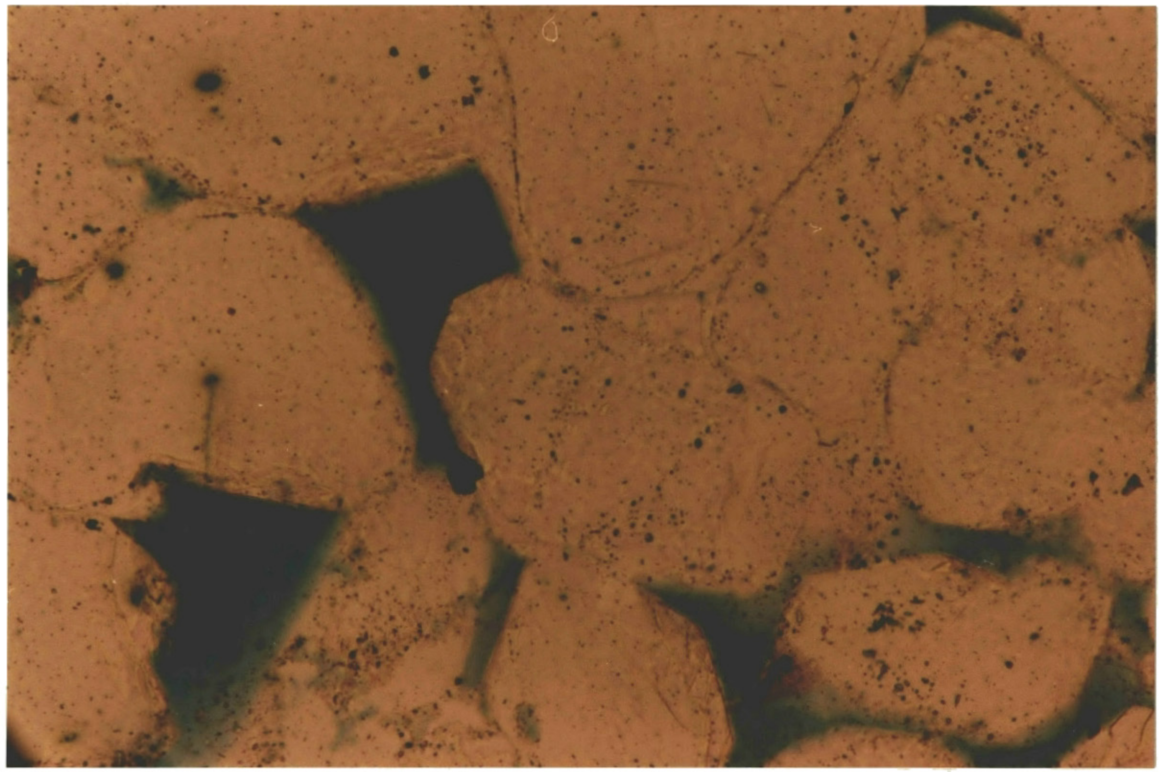


Figure 31. Photomicrograph of Syntaxial Quartz Overgrowths (x100 ppl).

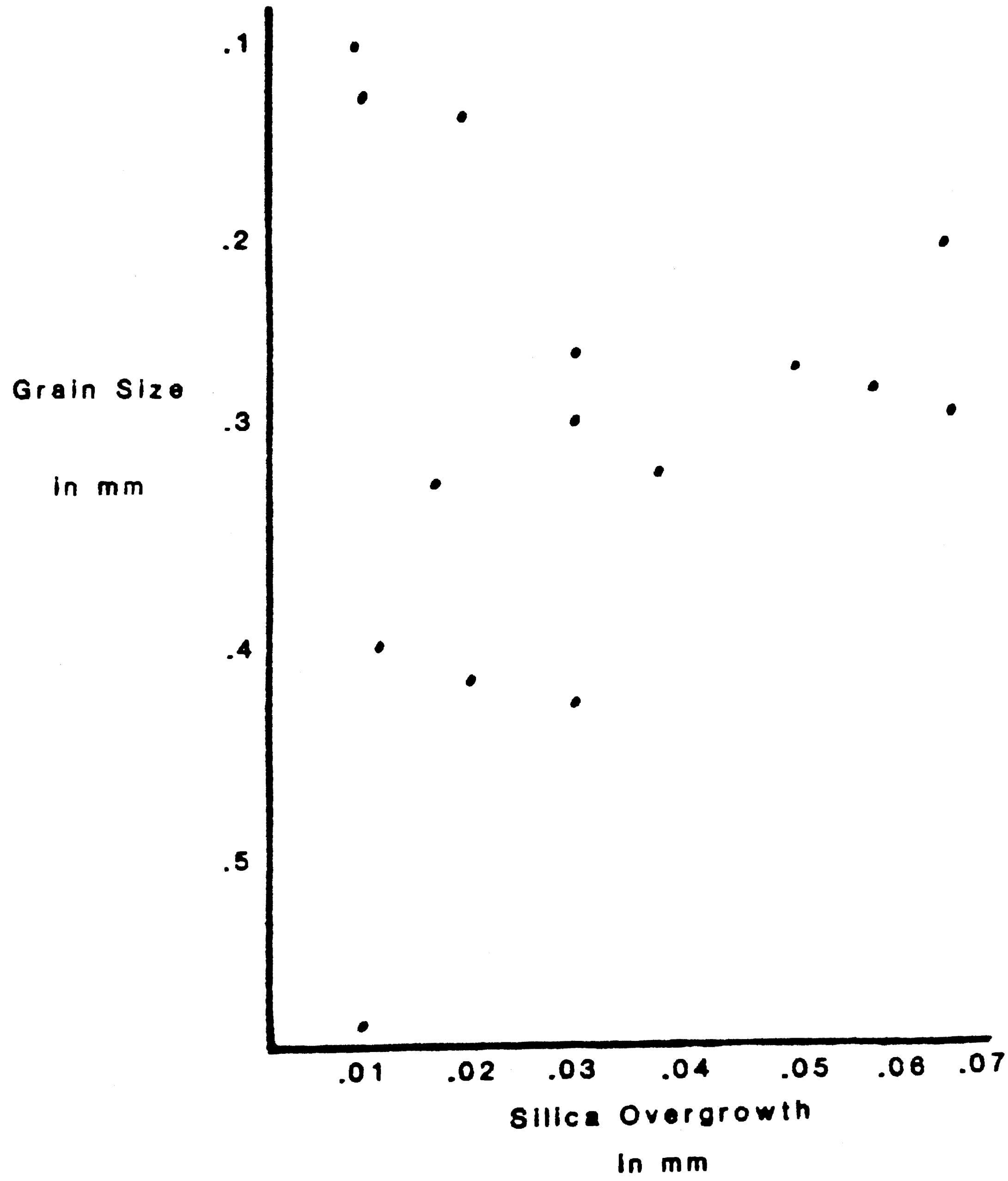



Figure 32. Graph Showing Comparison of Grain Size and Syntaxial Quartz Overgrowths.

result of reaction between silicic acid and bicarbonate ions, and (3) increase in solubility of quartz with increasing temperature. Because this study is intended to provide an overview of the diagenetic features of the Wilcox, the aforementioned mechanisms will not be discussed further.

Figure 33 shows a comparison of depth and percent silica cement per grain. From this graph, it appears that silica overgrowths increase with depth in the "Wilcox". (The absence of data from the middle of this graph is because of the depth-range of the dolomitic Marshall zone.)

## Authigenic Clays

Authigenic clays range from 1 to 4 percent in the samples. Chlorite and illite are the primary authigenic clays (2% and 3%) in samples (Figures 34 and 35). Chlorite commonly coats quartz grains and is preserved as "rims" after silica cementing has occurred. Clay "bridging" is also fairly common in the "Wilcox". Figures 36 and 37 show examples of clays coating quartz grains and blocking pore throats.

Based on x-ray diffraction peaks for the Wilcox, very little clay is present (Figures 38 and 39). The absence of clay in the rock, loss during extraction, or insufficient sampling will affect the pattern of the x-ray diffraction curves. These phenomona could account for the difference in

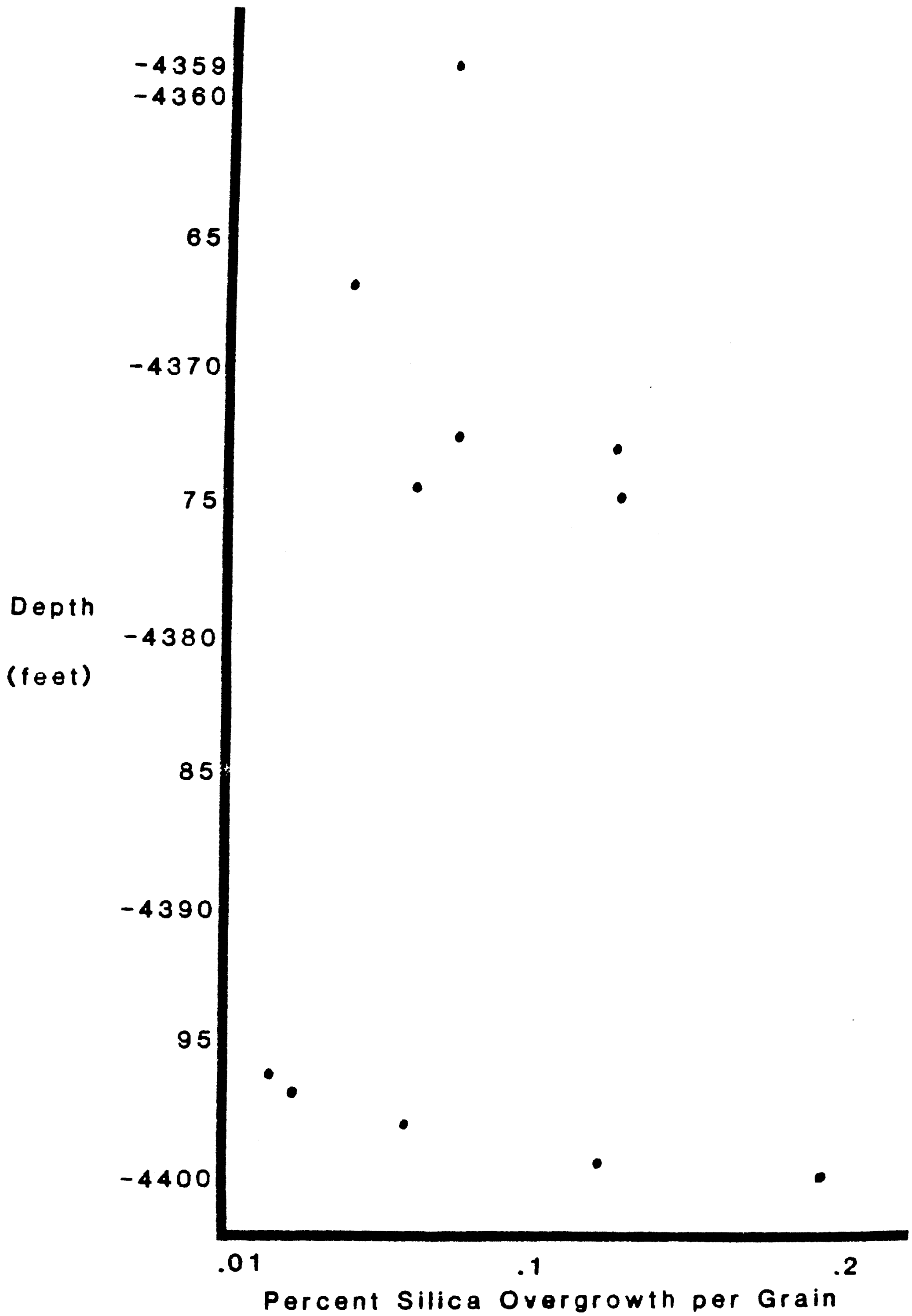



Figure 33. Graph Showing Depth versus Percent Syntaxial Overgrowth per Grain.

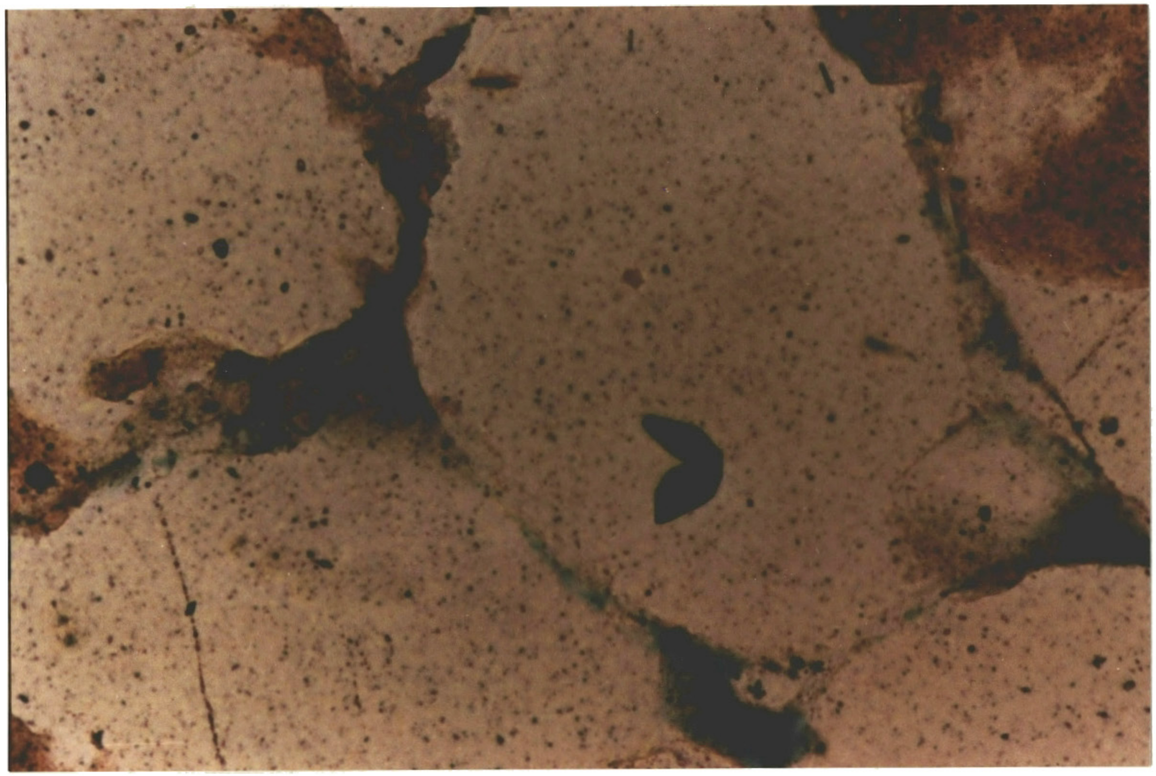


Figure 34. Photomicrograph of Authigenic Chlorite and Illite (x100 ppl).

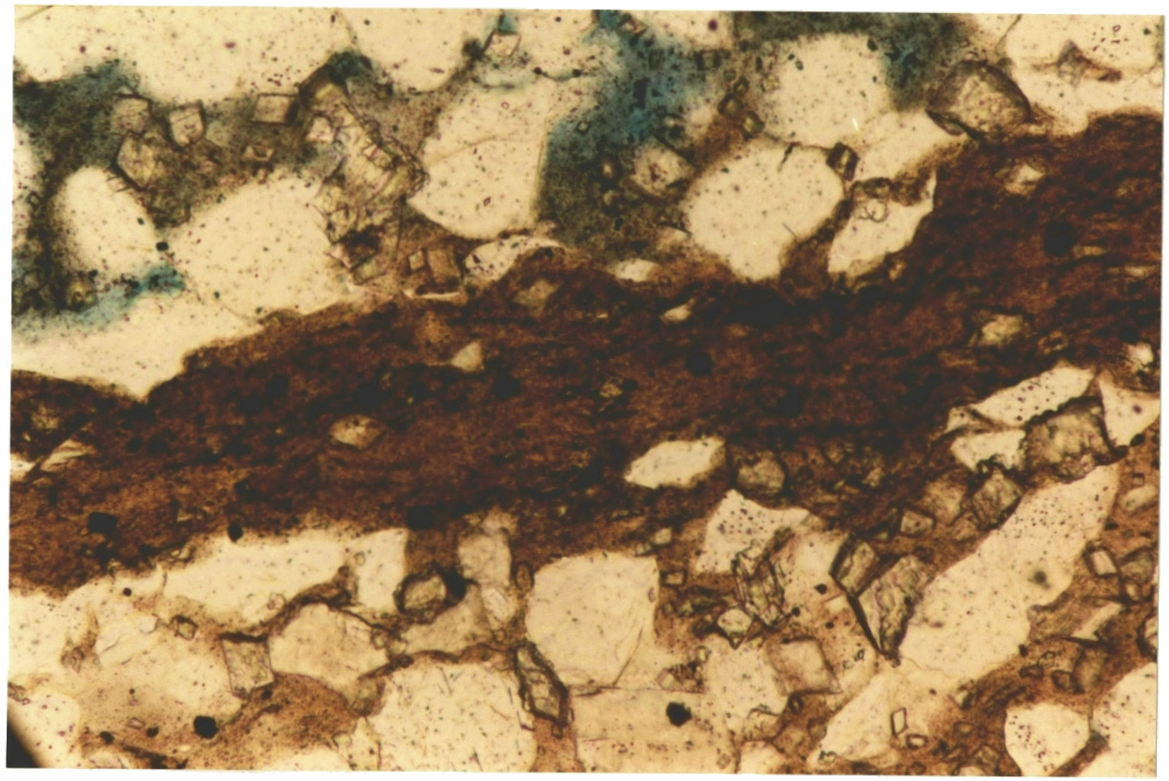


Figure 35. Photomicrograph of Authigenic Chlorite and Illite (x100 ppl).

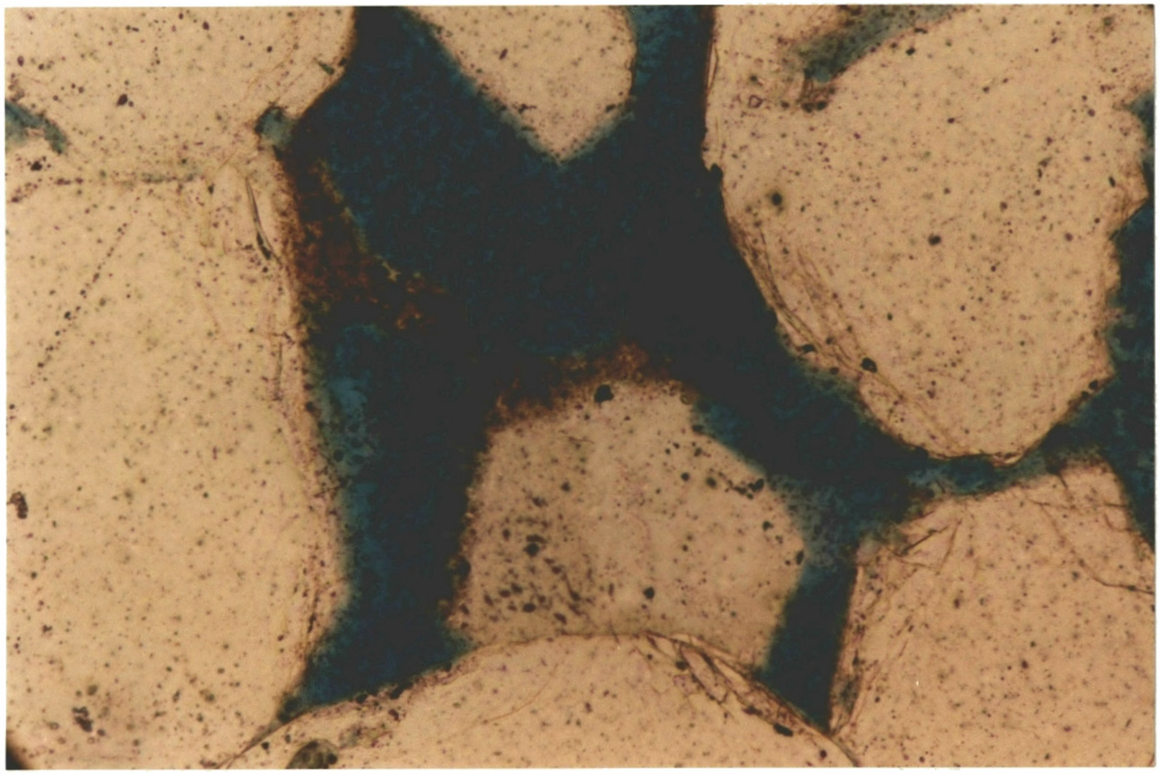


Figure 36. Photomicrograph Showing Authigenic Clays Coating Quartz Grains and Blocking Pore Throats (x100 ppl).

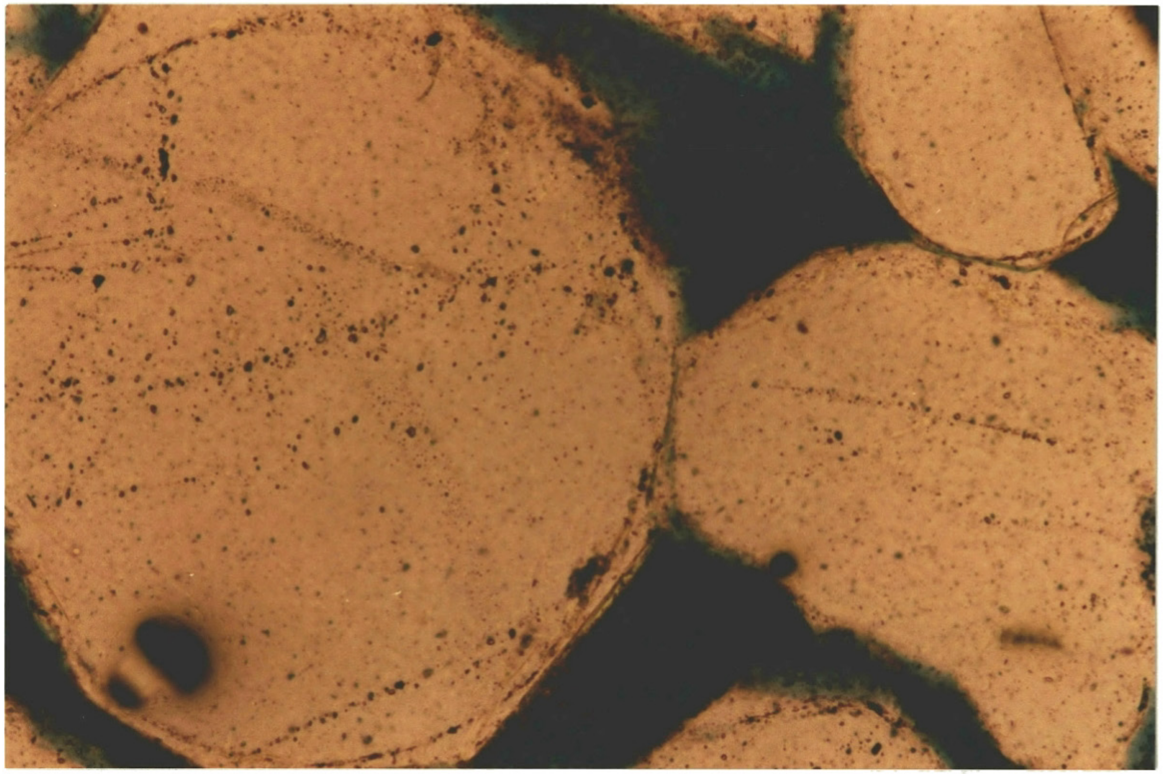


Figure 37. Photomicrograph Showing Authigenic Clays Coating Quartz Grains and Blocking Pore Throats (x100 ppl).

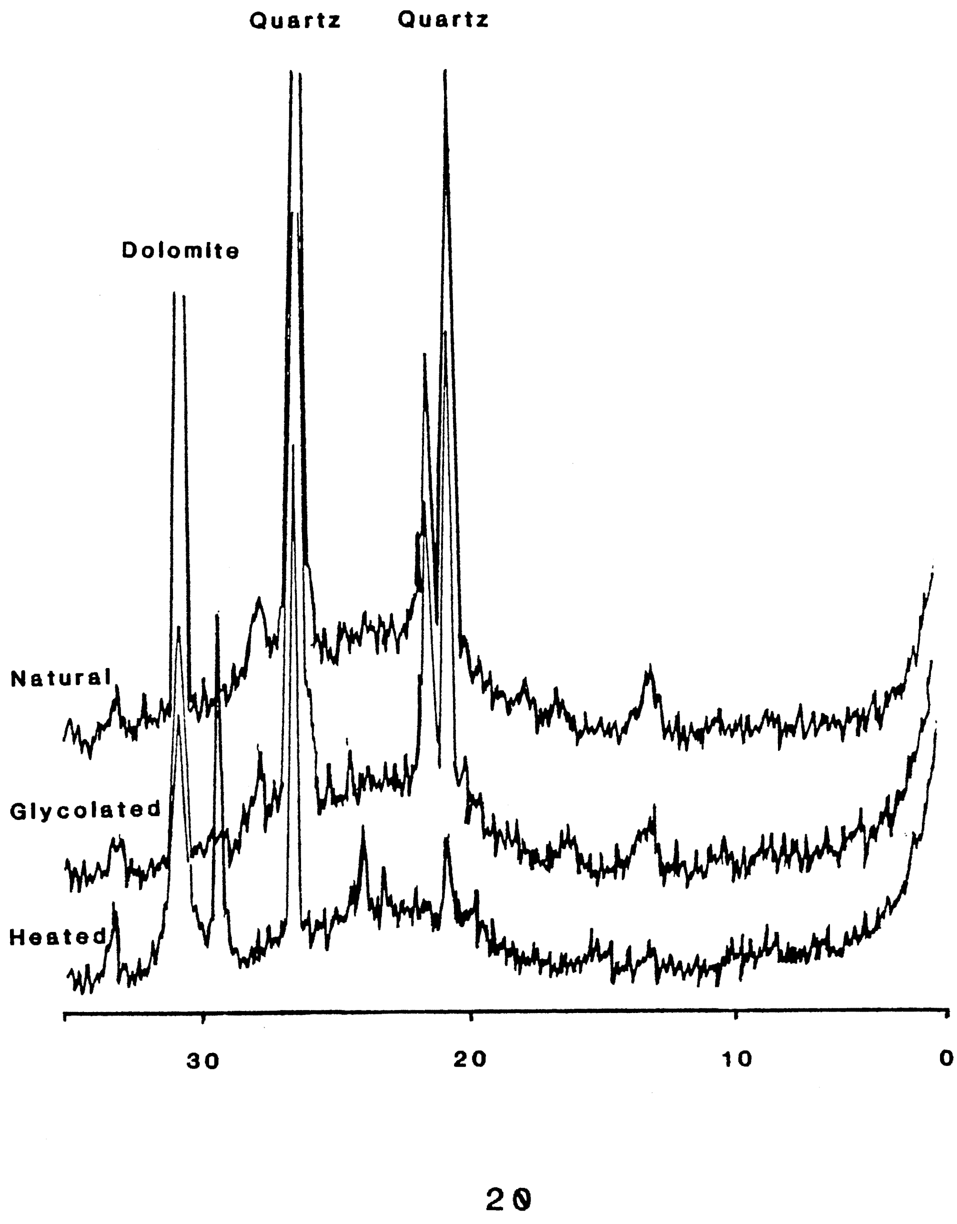



Figure 38. X-ray Diffraction Peaks of Authigenic Clays From "Wilcox" sandstones.

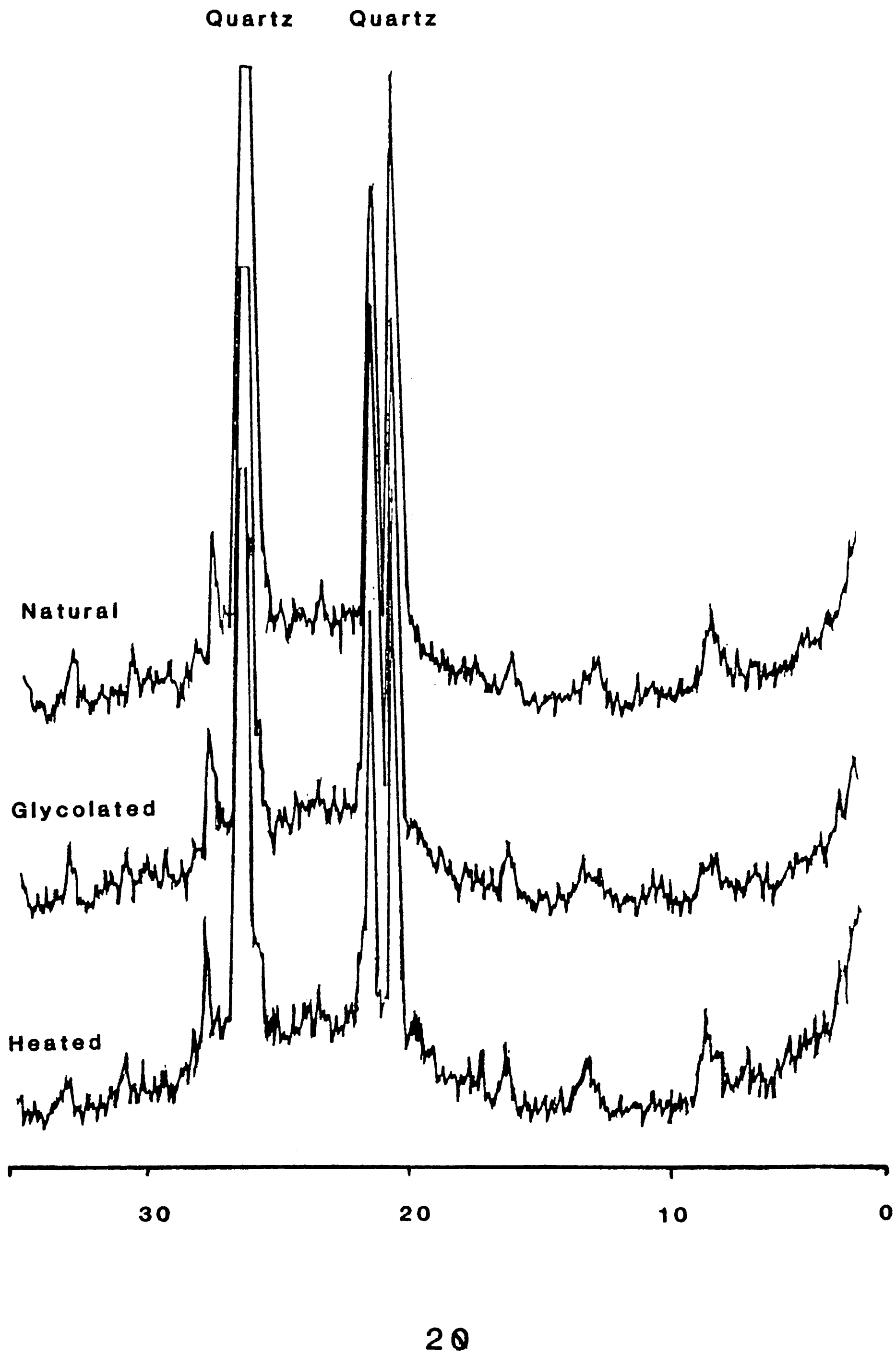



Figure 39. X-ray Diffraction Peaks of Authigenic Clays From "Wilcox" sandstones.

detection of clays by analysis of thin sections and by x-ray diffraction.

The small amounts of pyrite mentioned above generally are near concentrations of clays (Figures 40 and 41).

Hydrocarbons are present in the Wilcox in two forms, "moveable" hydrocarbons and "dead" oil. Figure 42 shows moveable hydrocarbons in a stylolite, and Figure 43 shows oil that has migrated through microspar and dolomitic zones. Dead oil remains trapped in pore spaces because its gravity is too low to allow migration through the reservoir rock.

Figure 44 shows dead oil of the type that is in the Wilcox.

## Diagenesis

The Wilcox has not been subjected to extremely high temperatures and intensive mechanical deformation as made evident by the lack of pressure-solution boundaries and the absence of undulose extinction in the quartz matrix. Changes in morphology and mineral composition were not extensive. Geochemical processes in the Wilcox were precipitation, alteration, replacement, and a small amount of dissolution (Figures 28, 45, and 24).

## Diagenetic History

Because the Wilcox consists of extremely clean sands and because these sands did not undergo intensive mechanical

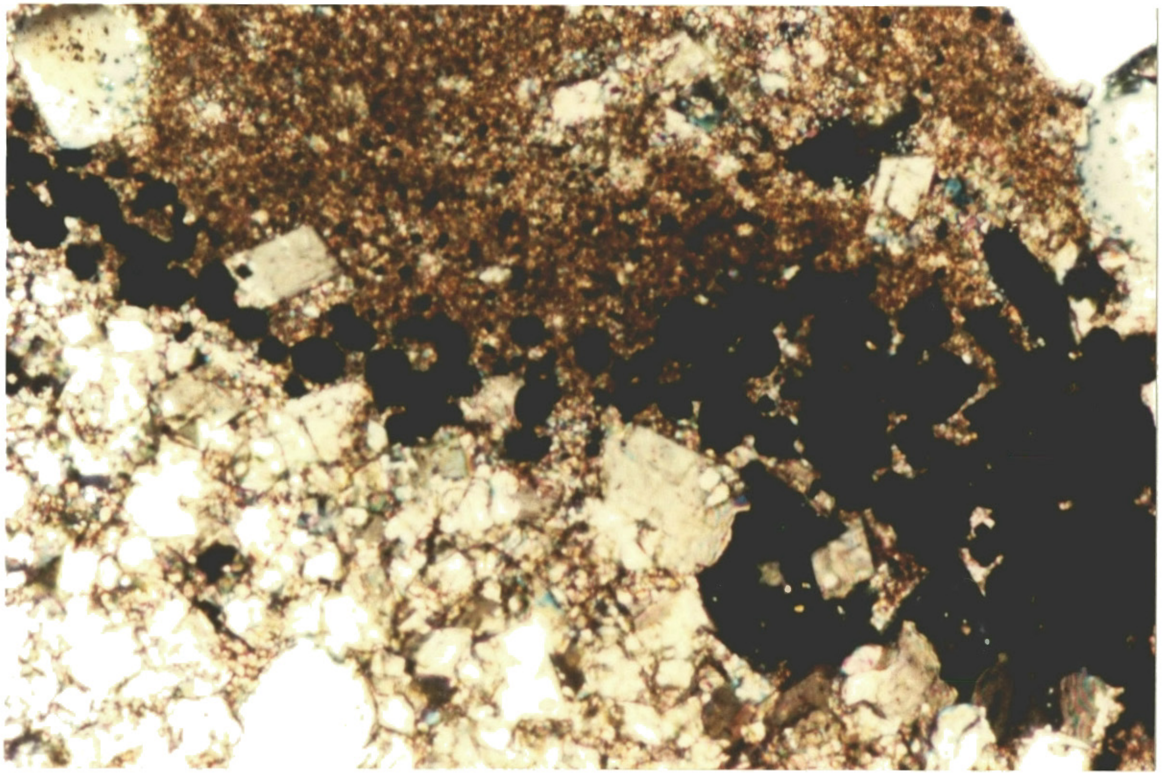


Figure 40. Photomicrograph Showing Authigenic Pyrite Near Clay Concentrations (x100 ppl).

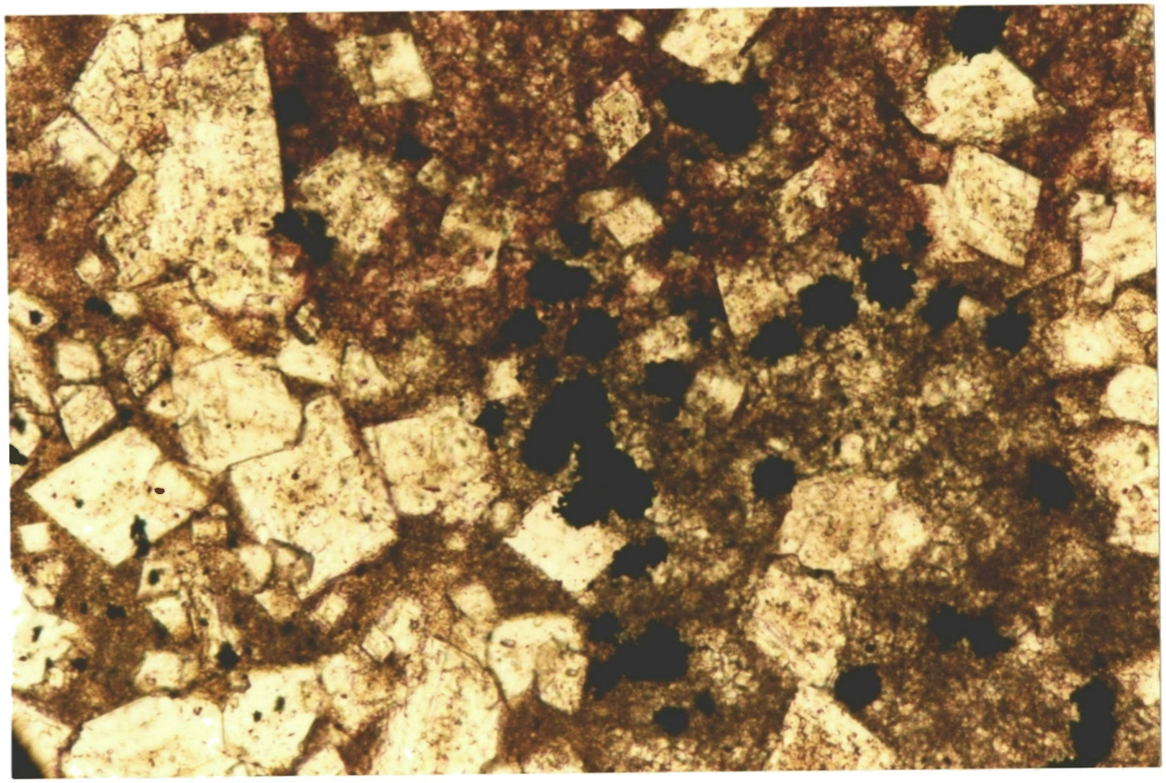


Figure 41. Photomicrograph Showing Authigenic Pyrite Near Clay Concentrations (x100 ppl).

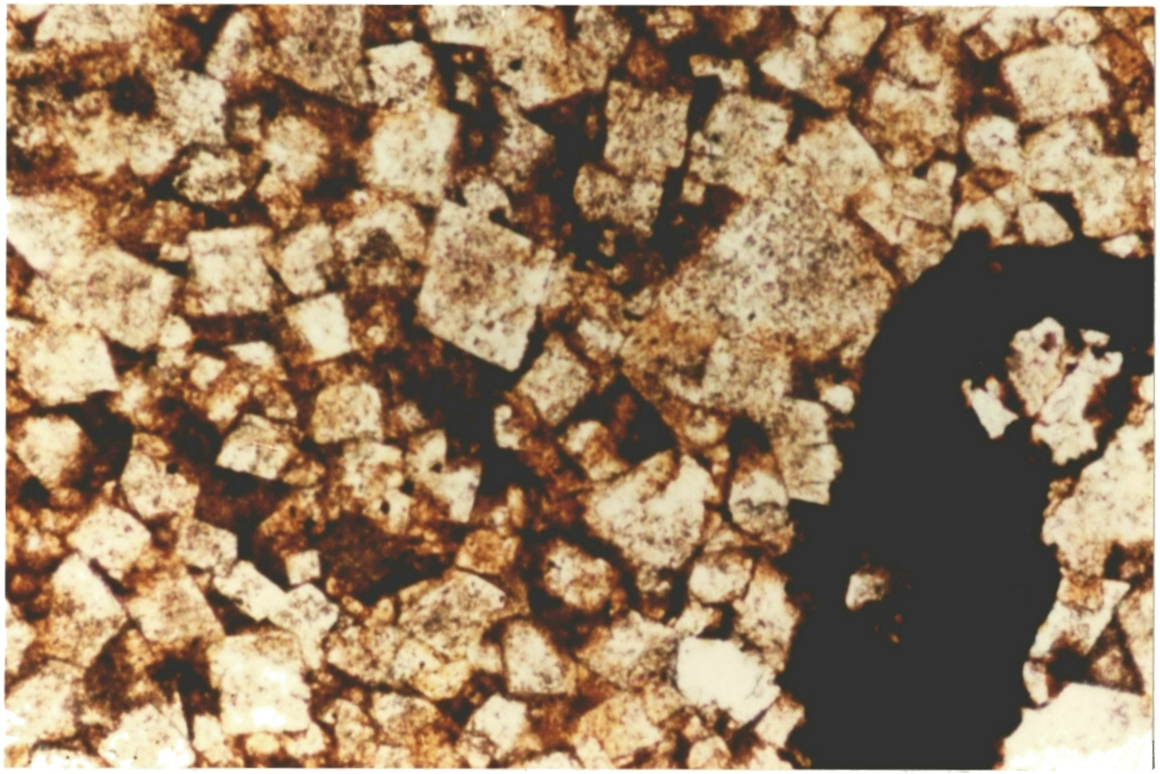


Figure 42. Photomicrograph of "Moveable" Hydrocarbons in a Stylolite (x100 ppl).

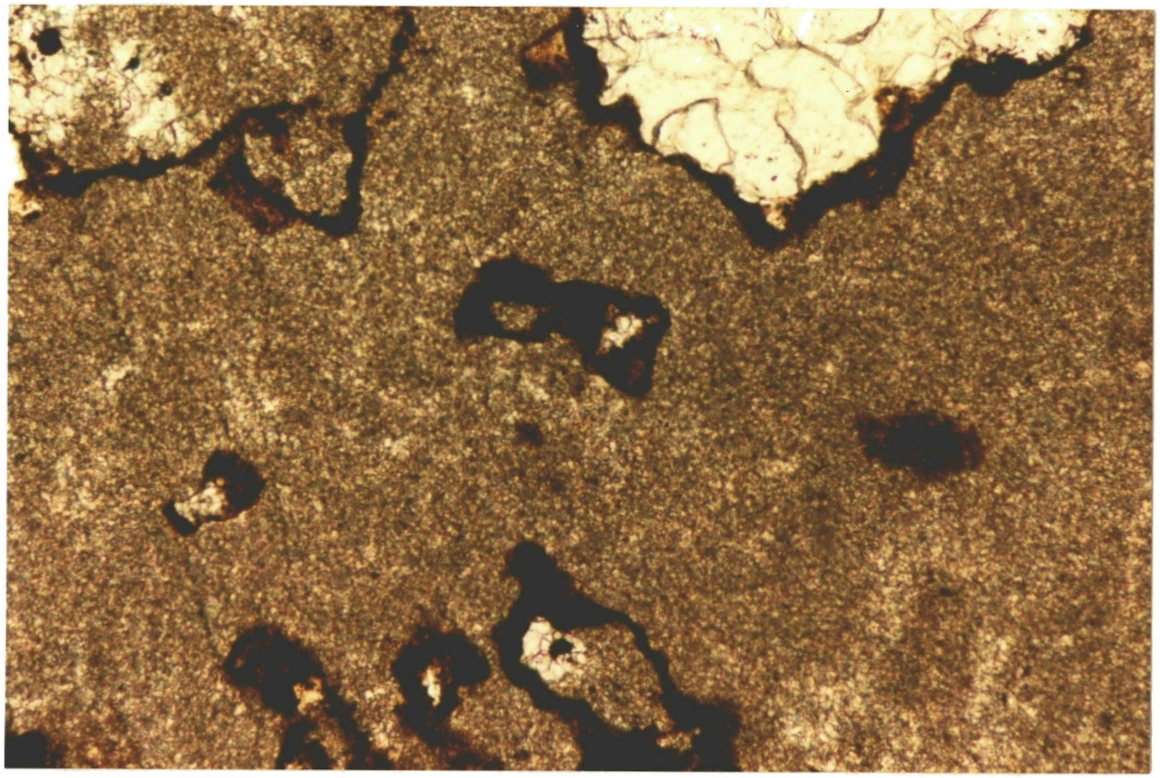


Figure 43. Photomicrograph Showing Oil Migrating Through Microspar and Dolomite (x100 ppl).

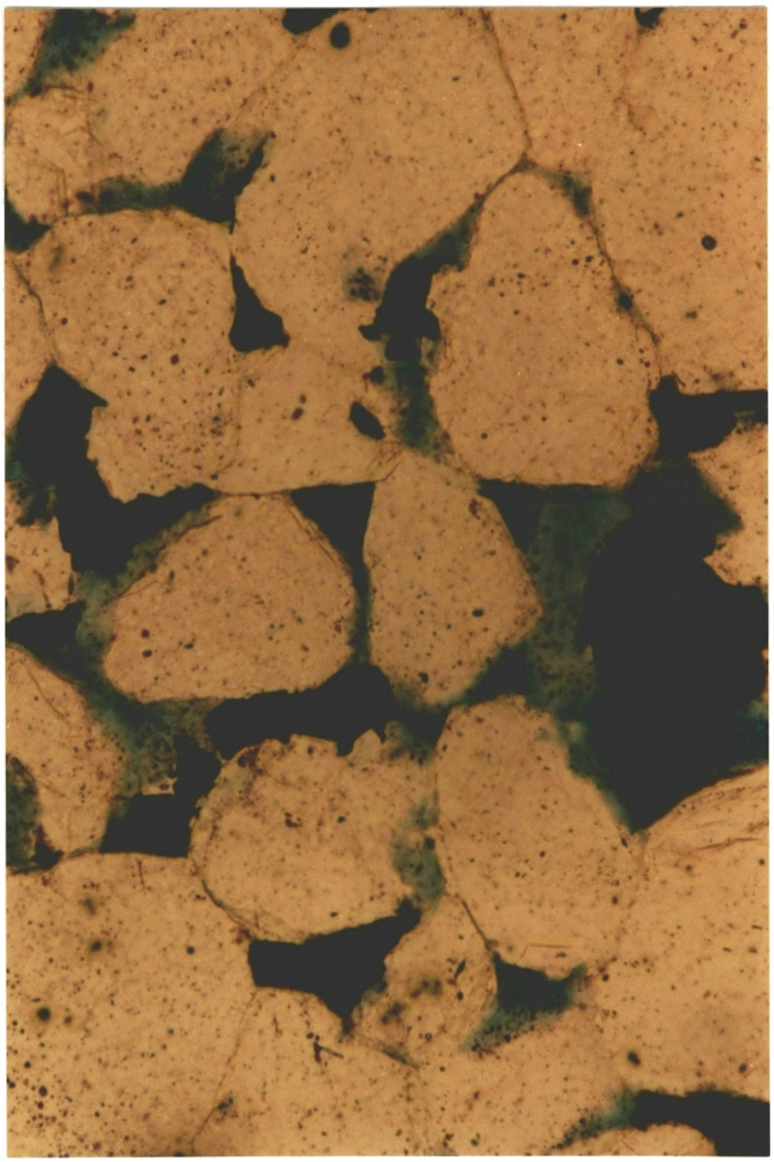


Figure 44. Photomicrograph of "Dead" Oil Trapped in the "Wilcox" sandstones (x100 ppl).

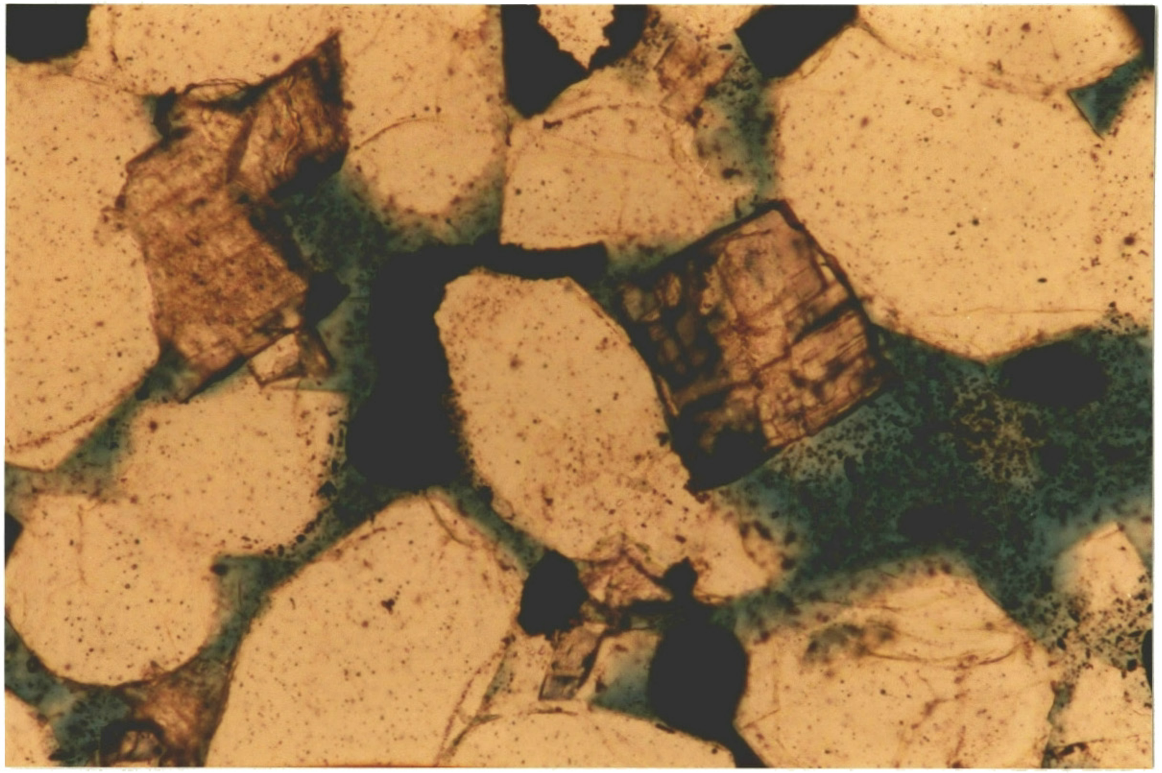


Figure 45. Photomicrograph Showing Dolomite Replacing Quartz and "Dead" Oil Trapped in Pore Spaces (x100 ppl).

deformation, the diagenetic history of the Wilcox seems relatively straight-forward.

The following interpretation is a general sequence of diagenetic events based on observations from analysis of thin sections, x-ray diffraction tests and literature that deals with diagenetic aspects of sandstones (Pittman and Wilson, 1977; Pittman, 1979; Pittman and Larese, 1986; Hoholick, Metarko and Potter, 1984):

1. Formation of dust rims (illite or chlorite) around quartz grains.
2. Precipitation of syntaxial quartz overgrowths.
3. Precipitation of calcite cement.
4. Precipitation of dolomite and dolomitization of calcite.
5. Precipitation of chlorite.
6. Dissolution of quartz and replacement by dolomite.
7. Precipitation of chlorite.
8. Precipitation of illite.
9. Migration of oil.
10. Precipitation of pyrite.

(See Figure 46 for illustrations of paragenetic sequence).

## Porosity

Acccording to Maxwell (1964), clean well-sorted sandstones normally have the most initial porosity, and they tend to maintain more porosity during burial than do poorly sorted sands that contain abundant matrix and minerals other

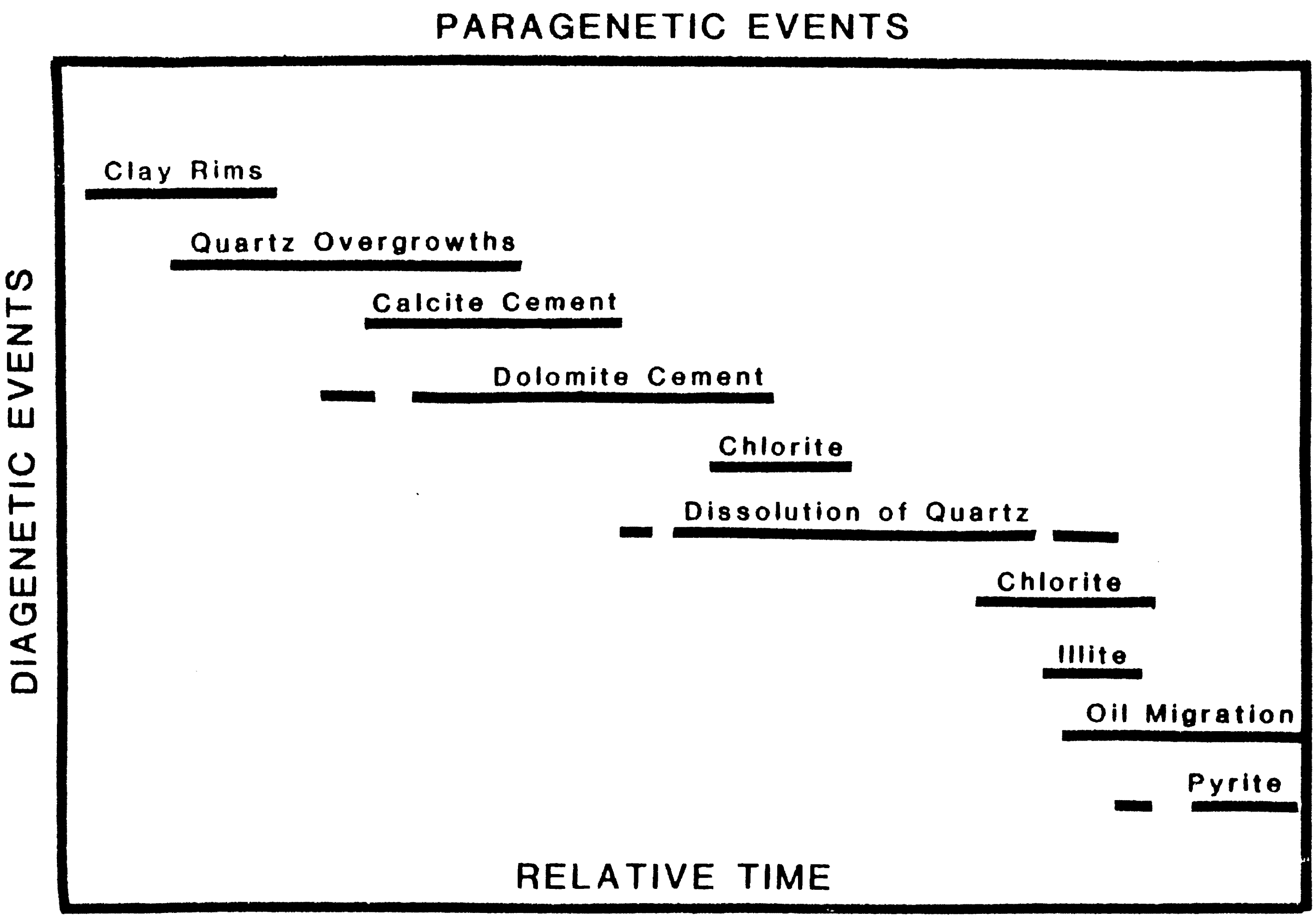



Figure 46. Paragenetic Sequence for the "Wilcox" Sandstones, Northeast Oklahoma Platform.

than quartz. Reduction of initial porosity is favored by increasing overburden pressure, high temperatures, greater age, moving formation water, and matrix and cement, which fill pore space and are deformed more easily than quartz (Krauskopf, 1959). Conversely, preservation of original porosity is favored by low temperatures, lesser age, stagnant formation water, absence of matrix and minerals other than quartz, and absence of excessive pore-fluid pressures (Maxwell, 1964).

In the area of investigation, diagenetic processes have begun to reduce the original porosity of the Wilcox. Based on thin-section analysis, the Wilcox contains porosity that ranges from about 3 to 15 percent (Figure 47). Primary porosity ranges from about 3 to about 13 percent and secondary porosity ranges from 0 to about 4 percent. Enlarged intergranular pore spaces owing to dissolution of metastable constituents (such as the detrital matrix), are the principle form of secondary porosity in the Wilcox. ?? Dissolution of calcite is shown in Figure 24. Low temperatures, possibly stagnant formation water, and absence of matrix and minerals other than quartz could account for the retention of primary porosity as suggested by Maxwell (1964).

According to Hoholick, Metarko and Potter (1984), the Saint Peter Sandstone of the Illinois Basin is considered equivalent to the Wilcox of Oklahoma. Diagenetic models developed for the Saint Peter -- from determination of the

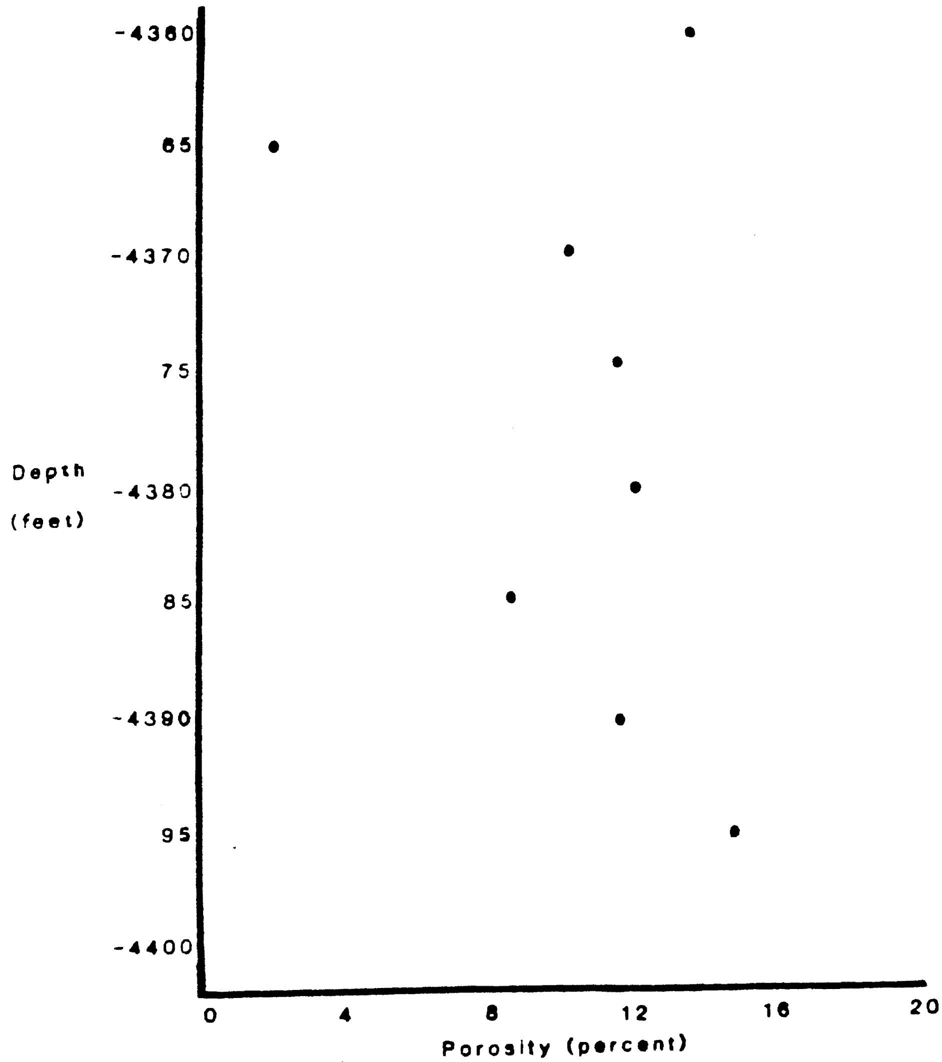



Figure 47. Graph Showing Depth versus Porosity for the Wilcox sandstones (data are from Myers 1-21 well).

distributions and types of cements and porosities -- could be applied in study of the Wilcox in Oklahoma. For example, trapping due to diagenetic processes does occur in the Wilcox; perhaps an in-depth study focusing upon the diagenetic aspects of the rocks would enhance the prediction of reservoir quality of the Wilcox.

The results of a regional investigation of the Saint Peter suggest that primary porosity is dominant from outcrop to 4,000 feet deep, whereas secondary porosity is dominant at depths greater than 4,000 feet (Hoholick, Metarko and Potter, 1984). Figure 48 shows the porosity-depth relationship of samples of the Saint Peter.

Furthermore, the cements in the Saint Peter are depth-dependent, define distinct regions in the basin, and include calcite, dolomite, anhydrite, chlorite, quartz overgrowths, chert, and chalcedony (Hoholick, Metarko and Potter, 1984). Figure 49 shows the distribution of dominant cements in the Illinois basin.

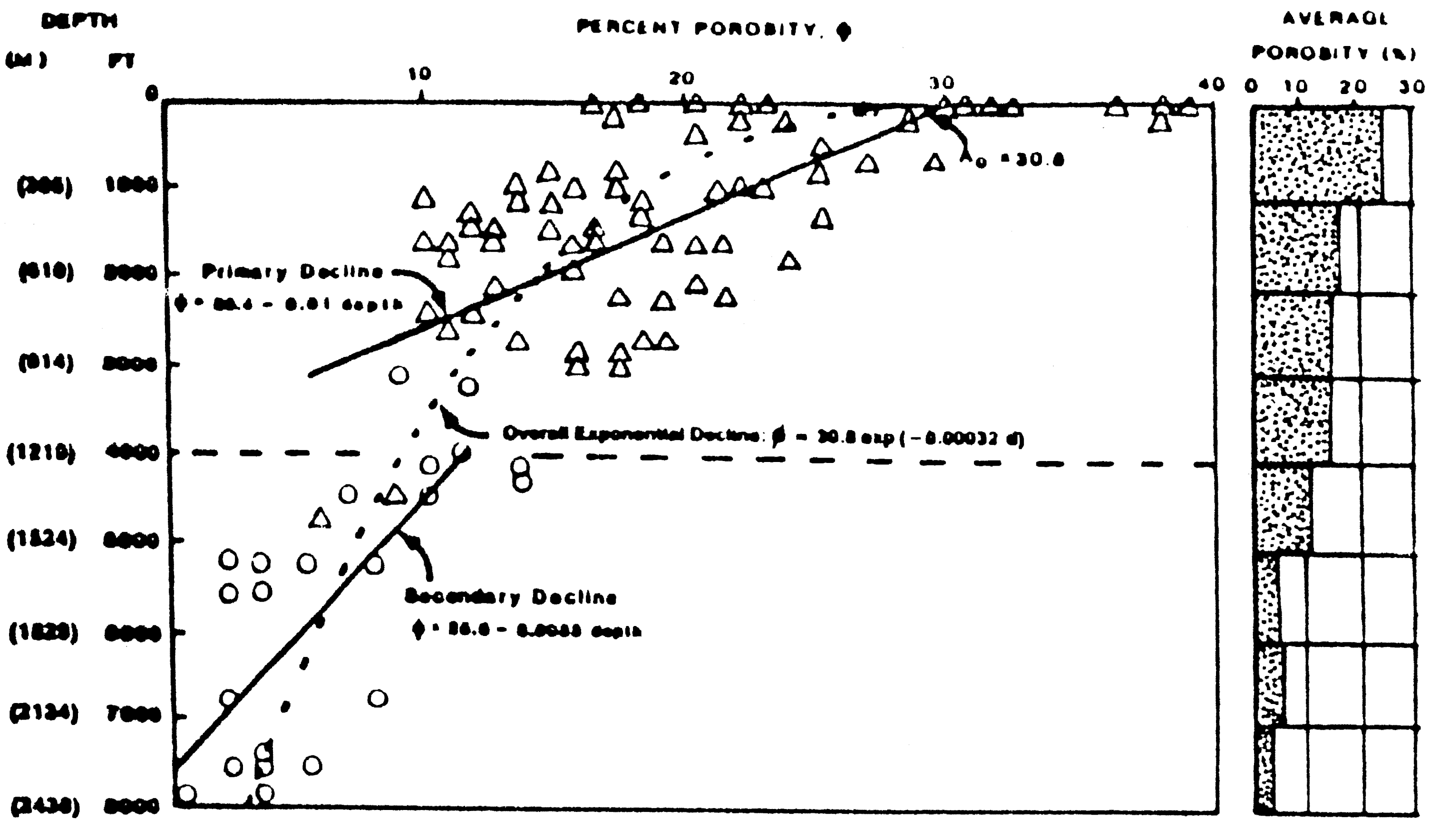



Figure 48. Graph Showing Porosity-Depth Relationships of Samples of St. Peter Sandstone (after Hoholick, Metarko, and Potter).

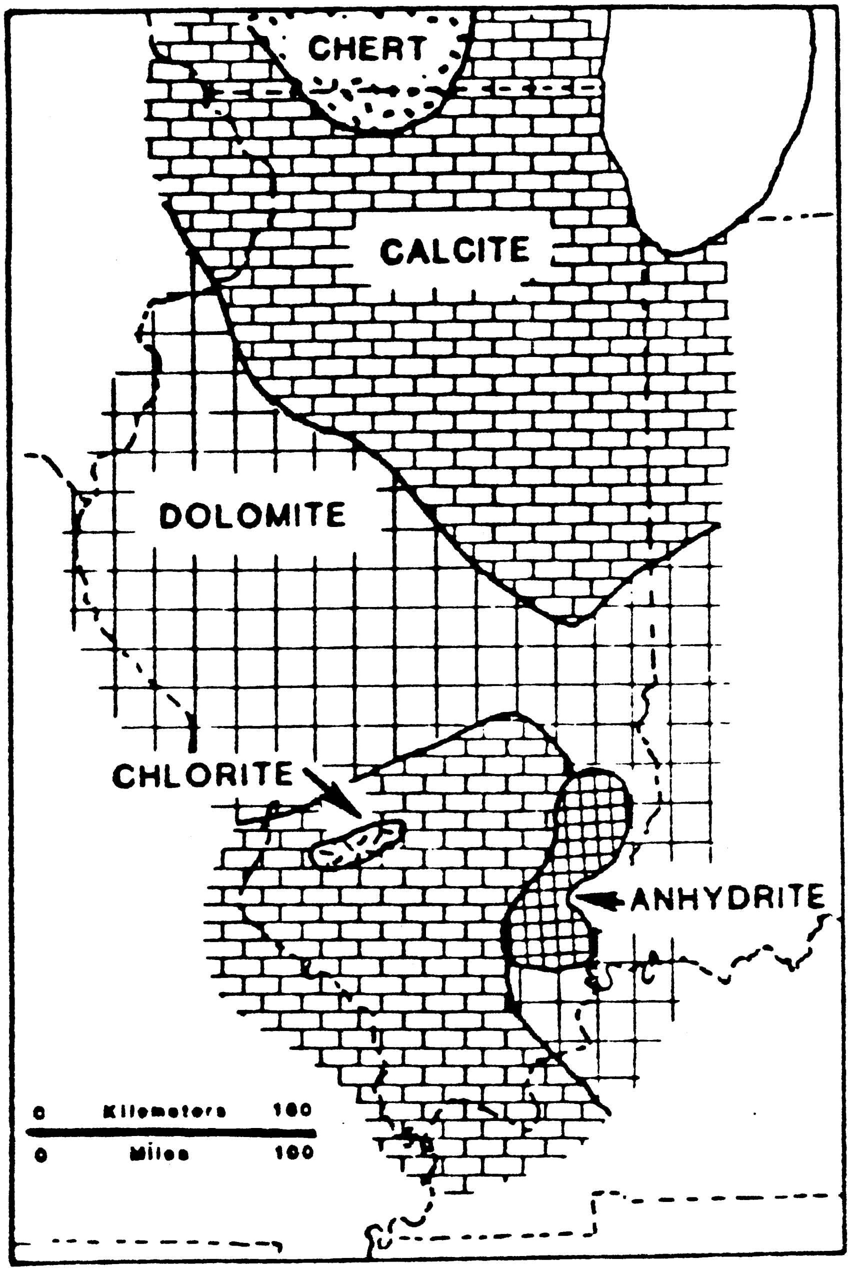



Figure 49. Map Showing Distribution of Dominant Cements in the Illinois Basin (after Honolick, Metarko, and Potter).

# CHAPTER V

# PETROLEUM GEOLOGY

## General Statement

Six oil and gas fields in the study area produce from the Wilcox sands. Locations and names of these fields are shown in Figure 50. Stillwater Southeast and Stillwater Airport fields are the more productive, with combined cumulative production of more than 634,358 barrels of oil as of September, 1986; however, the major amount of production from these fields was from other formations. The most recent discovery well in the Wilcox sands is the Southport Exploration, Inc., Crook No. 1-21, NW SW SW, section 21, T.19 N., R.3 e. This well, drilled in September, 1984, has produced 36,780 barrels of oil as of February, 1987. Table 1 shows the field names, numbers of producing wells in fields, discovery dates, cumulative production values of oil as of September, 1986, and present status of Wilcox producers in the area of investigation.

## Traps in Oil Fields Where Wilcox Sands Produce

Most oil produced from Wilcox sands in the study area is from traps controlled by anticlinal folding, or traps created by diagenetic changes in the reservoir rock.

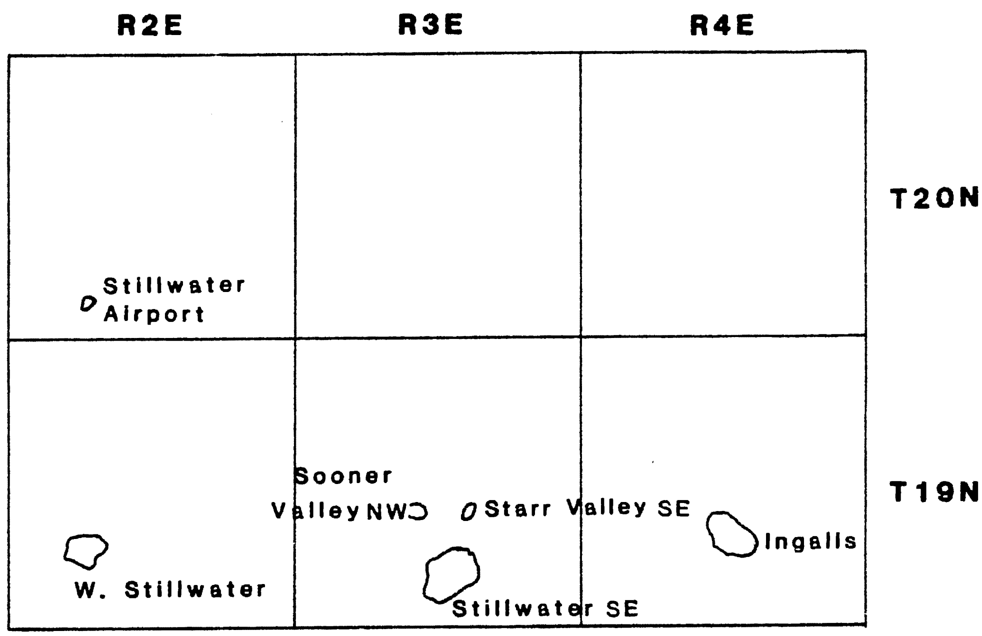



Figure 50. Map Showing Locations of Oil and Gas Fields with "Wilcox" Production.

TABLE 1

DATA OF FIELDS PRODUCING FROM "WILCOX" SANDSTONES

| Field Name | No. of Wells | Year Discovered | Cumulative Production (9/86)* | Status of "Wilcox" Production |
|---|---|---|---|---|
| Stillwater Airport | ? | 8/53 | 73,793 | Abandoned |
| W. Stillwater | ? | 9/81 | 52 bbls Gas (est.) | Abandoned |
| Stillwater SE | ? | 10/35 | 560,565 | Abandoned |
| Sooner Valley NW | 1 | 8/82 | 40,628 | Producing |
| Starr Valley SE | 1 | 12/84 | 22,603 | Producing |
| Ingalls | 3 | 6/79 | 6,831 | Producing |

*Cumulative production rounded in some instances.

Wilcox production at Stillwater Airport, West Stillwater, Stillwater Southeast, Sooner Valley Northwest, and Ingalls fields is from anticlinal folding with four-way closure (Figure 51). This kind of trap is by far the type from which the greatest amount of production has been realized in the study area.

The Starr Valley Southeast field is an example of a trap in which hydrocarbons are trapped by an impermeable barrier up-dip where the reservoir rock has been dolomitized (Figure 52). More traps of this type probably exist in the surrounding area (Helton, personal communication, 1987)

In addition to anticlinal folding with four-way closure and diagenetically-controlled traps, traps controlled by faulting are responsible for Wilcox production outside the study area (Umpleby, 1956). An example of fault-controlled production is the Ramsey pool located south of the study area. It covers a part of the eastern one-half of section 13, T.18 N., R.1 E. and the western one-half of section 18, T.18 N., R.2 E. (Figure 53). In the area east of the fault Wilcox production initially was 14,800 barrels of oil per day. West of the fault, production was 15,200 barrels of oil per day, although the Wilcox is 120 feet lower structurally on the eastern side (Figure 51) (Umpleby, 1956). The east and west sides of the fault act as separate reservoirs (Umpleby, 1956).

Cumulative production of Wilcox wells in the study area is approximately 705,000 barrels of oil. Wilcox production

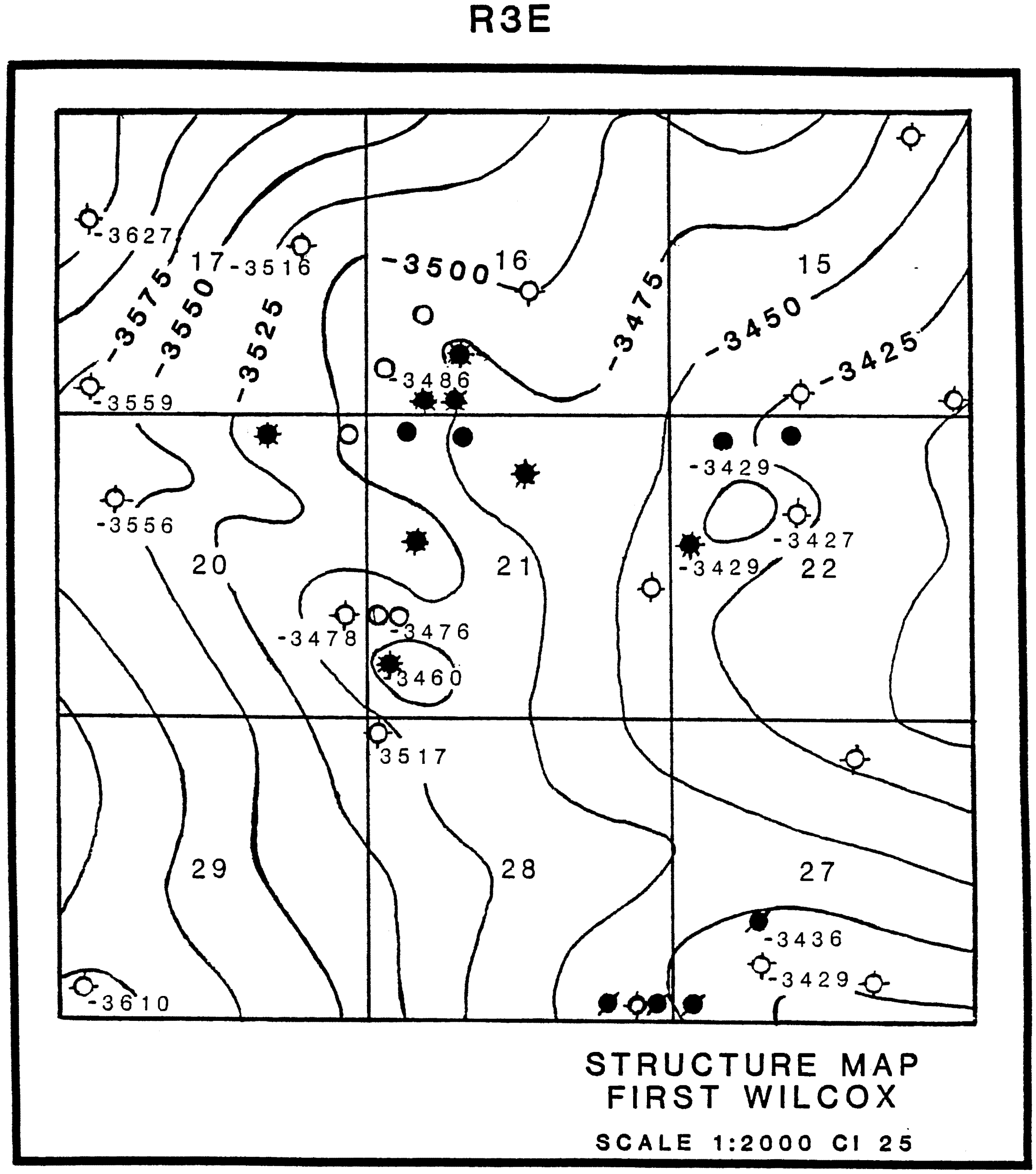



Figure 51. Example of production from First Wilcox in anticlinal trap with four-way closure (SW/4, SW/4, Sec. 21). Proprietary seismic data show eastward dip that justifies closure of the -3475 line.

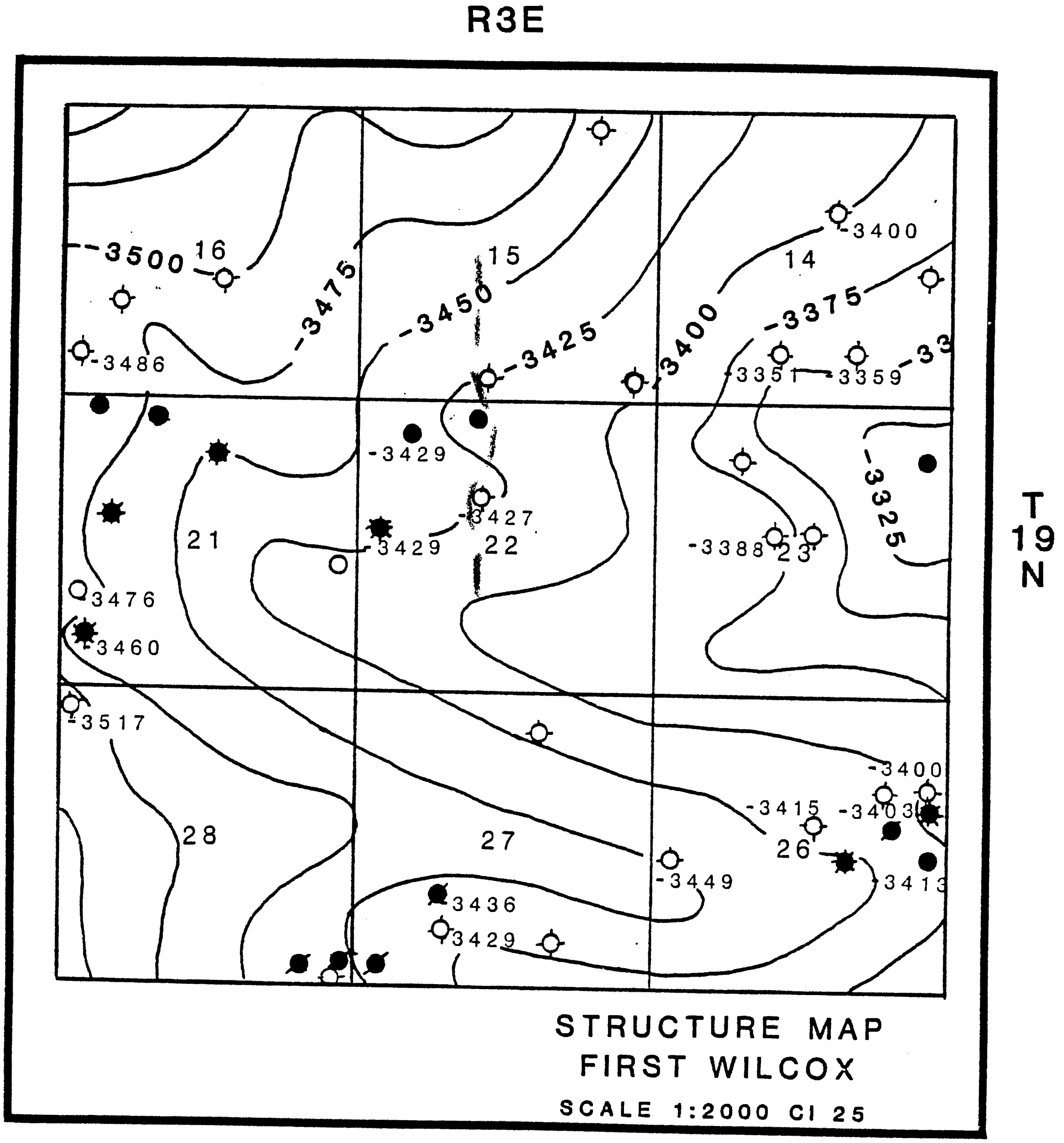



Figure 52. Example of production from First Wilcox in diagenetic trap. The three productive wells in NW/4, Sec. 22 are down-dip from dolomitized reservoir rock. Dashed line shows inferred general trend of permeability barrier.

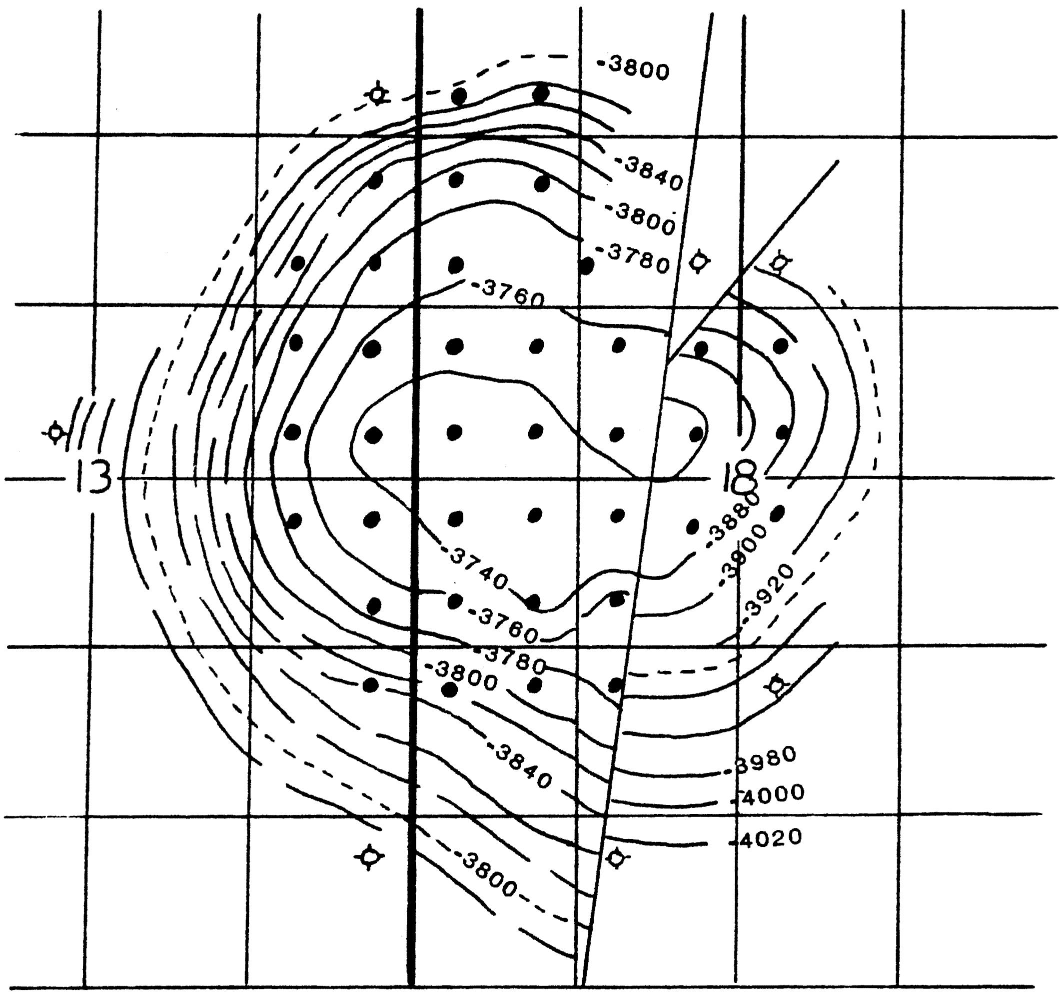



Figure 53. Structural Contour Map of the Ramsey Pool (after Umpleby, 1956).

in the study area has been almost as significant as Misener production, which is approximately 750,000 barrels of oil as of September, 1986. (All data are from standard production reports published by Petroleum Information, Inc.)

# CHAPTER VI

## CONCLUSIONS

The principle conclusions of this study are as follows:

1. The Hunton Group and Sylvan Shale are absent in the northeastern part of the study area. Erosion before deposition of the Woodford removed the aforementioned units.
2. In the study area, the Misener generally is in topographic "lows" of the pre-Woodford terrain.
3. The Wilcox sandstones studied primarily are quartzarenites.
4. Lithologic information from cores shows a general, ascending vertical sequence as follows: (1) massive, clean, crossbedded sandstone, (2) shaly, fossiliferous dolomite, and (3) clean, hydrocarbon-stained sandstone.
5. Structural contour maps show homoclinal, southwesterly dip and isopach maps show westerly thickening of the Wilcox and overlying units, including the Mississippi Lime.
6. The Wilcox is composed of shallow marine units that were deposited during Middle Ordovician time.

7. Two kinds of traps have been defined that account for Wilcox production in the study area: anticlinal folding with four-way closure, and diagenetically-controlled stratigraphic traps.
8. Primary porosity, owing to shallow depth, lack of intensive mechanical deformation and low temperatures is the predominant porosity type in the Wilcox.

## REFERENCES CITED

Akmal, M.G., 1950, Subsurface Geology of Northeast Lincoln and Southeast Payne Counties, Oklahoma: Shale Shaker, Vol. 3, No. 9, pp. 10-12.

Albano, M.A., 1975, Subsurface Stratigraphic Analysis "Cherokee" Group (Pennsylvanian), Northeast Cleveland County, Oklahoma: Shale Shaker, Vol. 25, Nos. 5, 6, 7, pp. 94-103; 114-124; 134-143.

Al-Shaieb, Z., 1987, Personal Communication.

Al-Shaieb, Z., and Shelton, J.W., 1981, Migration of Hydrocarbons and Secondary Porosity in Sandstones: Amer. Assoc. Petrol. Geol. Bull., Vol. 65, No. 11, pp. 2433-2436.

Barrett, E., 1986, Geologic History of Oklahoma: Mimeograph, Oklahoma State Univ., 23 pp.

Blatt, H., 1979, Diagenetic Processes in Sandstones: in Aspects of Diagenesis, Soc. Econ. Paleon. and Min., Spec. Publication No. 26, pp. 141-157.

Carozzi, A.V., 1960, Microscopic Sedimentary Petrography: John Wiley and Sons, Inc., Urbana, Illinois.

Cole, J.A., 1955, Subsurface Geology of East-central Lincoln County, Oklahoma: Shale Shaker Digest, Vol. 11, pp. 79-96.

Cram, I.H., 1930, Correlations of the Eastern Oklahoma Ordovician Section with that of the Arbuckles Region: Geol. Soc. of Amer. Bull., Vol. 43, p. 286.

Cronenwett, C., 1956, A Subsurface Study of the Simpson Group in East-central Oklahoma: Shale Shaker, Vol. 7, pp. 8-34.

Dapples, E.C., 1955, General Lithofacies Relationship of St. Peter Sandstone and Simpson Group: Amer. Assoc. Petrol. Geol. Bull., Vol. 39, pp. 444-467.

Decker, C.E., Merritt, C.A., and Harris, R.W., 1931, the Stratigraphy and Physical Characteristics of the Simpson Group: Okla. Geol. Surv. Bull., No. 55, pp. 16-47.

Disney, R.W., and Cronenwett, C.E., 1955, The Simpson Group Along the East Flank of the Anadarko Basin: Univ. of Okla., 4th Symposium, Subsurface Geol., Proc., pp. 107-115.

Donovon, N., 1986, Environmental Analysis of the Cool Creek Formation: Mimeograph, Okla. State Univ., 10 pp.

Elliott, T., 1986, Siliciclastic Shorelines: in Sedimentary Environments and Facies, Dept. of Earth Sciences, Univ. of Oxford, pp. 155-188.

Galloway, W.E., and Hobday, D.K., 1983, Terrigenous Clastic Depositional Systems: Springer-Verlag, New York, pp. 115-387.

Graves, J.M., 1955, Subsurface Geology of a Portion of Lincoln and Payne Counties, Oklahoma: Shale Shaker, Vol. 6, No. 1, pp. 6-27.

Grier, T.E., 1987, Personal Communication.

Ham, W.E., 1945, Geology and Glass Sand Resources of Central Arbuckle Mountains, Oklahoma: Okla. Geol. Surv. Bull. 65, p. 103.

Hayes, J.B., 1979, Sandstone Diagenesis - The Hole Truth: in Aspects of Diagenesis, Soc. Econ. Paleon. and Min. Spec. Publ. No. 26, pp. 127-139.

Helton, J.R., 1987, Personal Communication.

Hoholick, J., Metarko, T., and Potter, P., 1984, Regional Variations of Porosity and Cements: St. Peter and Mount Simon Sandstones in Illinois Basin: Amer. Assoc. Petrol. Geol. Bull., Vol. 68, No. 6, pp. 753-764.

Holden, F.T., 1965, The Simpson Group of the Arkoma Basin, Oklahoma and Arkansas: Tulsa Geol. Soc. Digest, Vol. 33, pp. 134-143.

Huffman, G.G., 1965, Simpson Group in Northeastern Oklahoma: Tulsa Geol. Soc. Digest, Vol. 33, pp. 109-129.

Huffman, G.G., et al., 1958, Geology of the Flanks of the Ozark Uplift, Northeast Oklahoma: Okla. Geol. Surv. Bull. 77, 81 pp.

Ireland, H.A., 1965, Regional Depositional Basin and Correlations of Simpson Group: Tulsa Geol. Soc. Digest, Vol. 33, pp. 74-89.

Johnson, H.D., and Baldwin, C.T., 1986, Shallow Siliciclastic Seas: in Sedimentary Environments and Facies, Dept. of Earth Sciences, Univ. of Oxford, pp. 229-282.

Jordan, L., 1957, Subsurface Stratigraphic Names of Oklahoma: Okla. Geol. Survey Guidebook VI, 220 pp.

Kendall, C.G., and Wolfgang, S., 1982, Relative Changes in Sea Level and its Effect Upon Carbonate Deposition: Shale Shaker, Sept., pp. 1-18.

Kittrick, J.A., and Hope, E.W., 1963, A Procedure for the Particle-Size Separation of Soils for X-ray Diffraction Analysis: Soil Science, Vol. 96, No. 5, pp. 319-325.

Kochick, J.P., 1978, Petroleum Geology of the Misener Sandstone in Parts of Payne and Lincoln Counties, Unpublished M.S. Thesis, Oklahoma State University.

Krauskopf, K.B., 1979, Introduction to Geochemistry, McGraw-Hill Book Company, New York, 617 pp.

Levorson, A.I., 1928, Geology of Seminole County: Okla. Geol. Survey Bull. 40, Vol. 3, pp. 307-312.

Longman, M.W., 1981, Deposition of the Bromide Formation, Arbuckle Mountains, Oklahoma: Ontogeny of an Ancient Carbonate Shelf: Shale Shaker, Oct., pp. 1-18.

Maxwell, J.C., 1964, Influence of Depth, Temperature, and Geologic Age on Porosity of Quartzose Sandstone: Amer. Assoc. Petrol. Geol. Bull., Vol. 48, pp. 697-709.

Montgomery, J.H., 1951, Ordovician Formations in the Illinois River Valley of Northeastern Oklahoma: Tulsa Geol. Soc. Digest, Vol. 19, pp. 137-168.

Moore, C.A., and Larese, R.E., 1986, The Influence of Diagenesis on Porosity and Permeability Development within Reservoir Sandstones: Amoco Production Co. Research Center, Tulsa, Oklahoma.

Morgan, J.T., and Gordon, D.T., 1970, Influence of Pore Geometry on Water-Oil Relative Permeability: Jour. Petrol. Tech., No. 10, pp. 1199-1208.

Newman, M.L., 1965, The Simpson Play - Some Notes and Reminiscences: Tulsa Geol. Soc. Digest, Vol. 33, pp. 212-214.

Odom, I.E., Willand, T.N., and Lassin, R.J., 1979, Paragenesis of Diagenetic Minerals in the St. Peter Sandstone (Ordovician), Wisconsin and Illinois: in Aspects of Diagenesis, Soc. Econ. Paleon. and Min. Spec. Publication, No. 26, pp. 425-443.

Pittman, E.D., 1979, Porosity, Diagenesis and Productive Capability of Sandstone Reservoirs: in Aspects of Diagenesis, Soc. Econ. Paleon. and Min. Spec. Publication, No. 26, pp. 159-173.

Pittman, E.D., and Larese, R.E., 1986, The Influence of Diagenesis on Porosity and Permeability Development within Reservoir Sandstones: Amoco Production Co. Research Center, Tulsa, Oklahoma.

Reineck, H.E., and Singh, I.B., 1980, Depositional Sedimentary Environments: Springer-Verlag, New York, 549 pp.

Roedder, E., 1979, Fluid Inclusion Evidence on the Environments of Sedimentary Diagenesis, a Review: in Aspects of Diagenesis, Soc. Econ. Paleon. and Min. Spec. Publication, No. 26, pp. 89-107.

Schmidt, V., and McDonald, D.A., 1979, The Role of Secondary Porosity in the Course of Sandstone Diagenesis: in Aspects of Diagenesis, Soc. Econ. Paleon. and Min. Spec. Publication, No. 26, pp. 209-225.

Schramm, M. Jr., 1964, Paleogologic and Quantitatives Lithofacies Analysis, Simpson Group, Oklahoma: Amer. Assoc. Petrol. Geol. Bull., Vol. 48, No. 7, pp. 1164-1195.

Schramm, M. Jr., 1965, Distribution of Simpson Production, Central and Mid-continent Region: Tulsa Geol. Soc. Digest, Vol. 33, pp. 130-132.

Sellwood, B.W., 1986, Shallow-marine Carbonate Environments: in Sedimentary Environments and Facies, Dept. of Earth Sciences, Univ. of Oxford, pp. 283-341.

Shelton, J.W., 1973, Models of Sand and Sandstone Deposits: A Methodology for Determining Sand Genesis and Trend: Oklahoma Geological Survey Bull. 118, 122 pp.

Shelton, J.S., Ross, J.S., Garden, A.J., and Franks, J.L., 1985, Geology and Mineral Resources of Payne County, Oklahoma: Okla. Geol. Survey Bull. 137, pp. 24-25.

Statler, A., 1965, Stratigraphy of the Simpson Group in Oklahoma: Tulsa Geol. Soc. Digest, Vol. 33, pp. 162-210.

Stewart, G., 1987, Personal Communication.

Stout, J.L., 1964, Pore Geometry as Related to Carbonate Stratigraphic Traps: Amer. Assoc. Petrol. Geol. Bull., Vol. 48, pp. 329-337.

Sutherland, P.K., and Manger, W.L., 1979, Mississippian-Pennsylvanian Shelf-to-Basin Transition Ozark and Quachita Regions, Oklahoma and Arkansas: Okla. Geol. Survey, Guidebook 19, pp. 10-13.

Taff, J.A., 1902, Atoka Folio, Indian Territory: U.S. Geol. Survey Geol. Atlas, Folio 79.

Ulrich, E.O., 1911, Revision of the Paleozoic System, Geol. Soc. Amer., Vol. 22, No. 3.

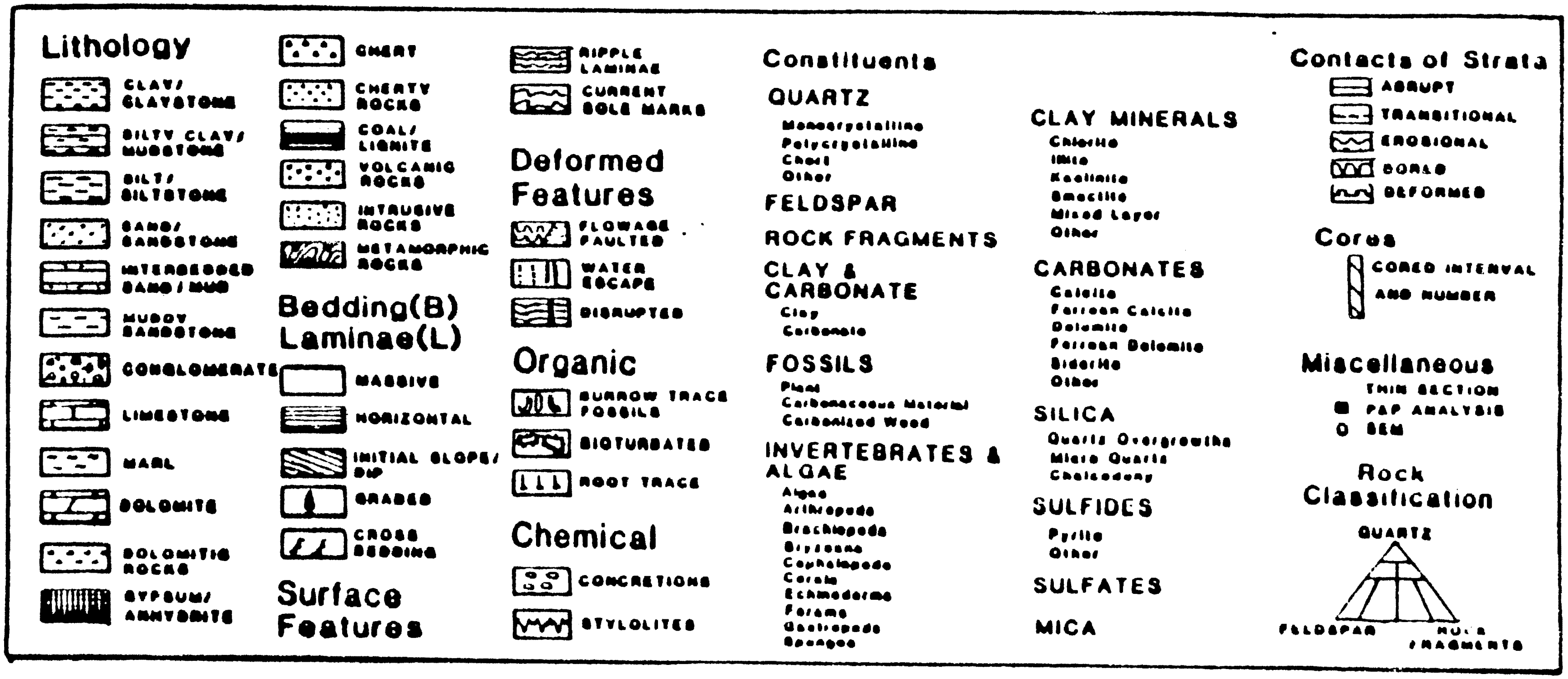
Umpleby, S.S., 1956, Faulting, Accumulation, and Fluid Distribution in Ramsey Pool, Payne County, Oklahoma: Amer. Assoc. Petrol. Geol. Bull., Vol. 40, No.1, pp. 122-139.

Wilson, M.D., and Pittman, E.d., 1977, Authigenic Clays in Sandstones: Recognition and Influence on Reservoir Properties and Paleoenvironmental Analysis: Jour. Sed. Petrol., Vol. 47, No.1, pp. 3-31.

Weirich, T.E., 1953, Shelf Principle of Oil Origin, Migration, and Accumulation: Amer. Assoc. Petrol. Geol. Bull, vol. 37, pp. 2027-2045.

APPENDIX

CORE DESCRIPTIONS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SILTY CLAY/ MUDSTONE
SILT/ SILTSTONE
SAND/ SANDSTONE
INTERBEDDED SAND / MUD
MUDDY SANDSTONE
CONGLOMERATE
LIMESTONE
MARL
DOLOMITE
DOLOMITIC ROCKS
GYPSUM/ ANHYDRITE
CHERT
CHERTY ROCKS
COAL/ LIGNITE
VOLCANIC ROCKS
INTRUSIVE ROCKS
METAMORPHIC ROCKS
Bedding(B) Laminae(L)
MASSIVE
HORIZONTAL
INITIAL SLOPE/ DIP
GRADED
CROSS BEDDING
Surface Features
RIPPLE LAMINAE
CURRENT SOLE MARKS
Deformed Features
FLOWAGE FAULTED
WATER ESCAPE
DISRUPTED
Organic
BURROW TRACE FOSSILS
BIOTURBATED
ROOT TRACE
Chemical
CONCRETIONS
STYLOLITES
Constituents
QUARTZ
Monocrystalline
Polycrystalline
Chert
Other
FELDSPAR
ROCK FRAGMENTS
CLAY & CARBONATE
Clay
Carbonate
FOSSILS
Plant
Carbonaceous Material
Carbonized Wood
INVERTEBRATES & ALGAE
Algae
Arthropods
Brachiopods
Bryozoans
Cephalopods
Corals
Echinoderms
Forams
Gastropods
Sponges
CLAY MINERALS
Chlorite
Illite
Kaolinite
Smectite
Mixed Layer
Other
CARBONATES
Calcite
Ferroan Calcite
Dolomite
Ferroan Dolomite
Siderite
Other
SILICA
Quartz Overgrowths
Micro Quartz
Chalcedony
SULFIDES
Pyrite
Other
SULFATES
MICA
Contacts of Strata
ABRUPT
TRANSITIONAL
EROSIONAL
BORED
DEFORMED
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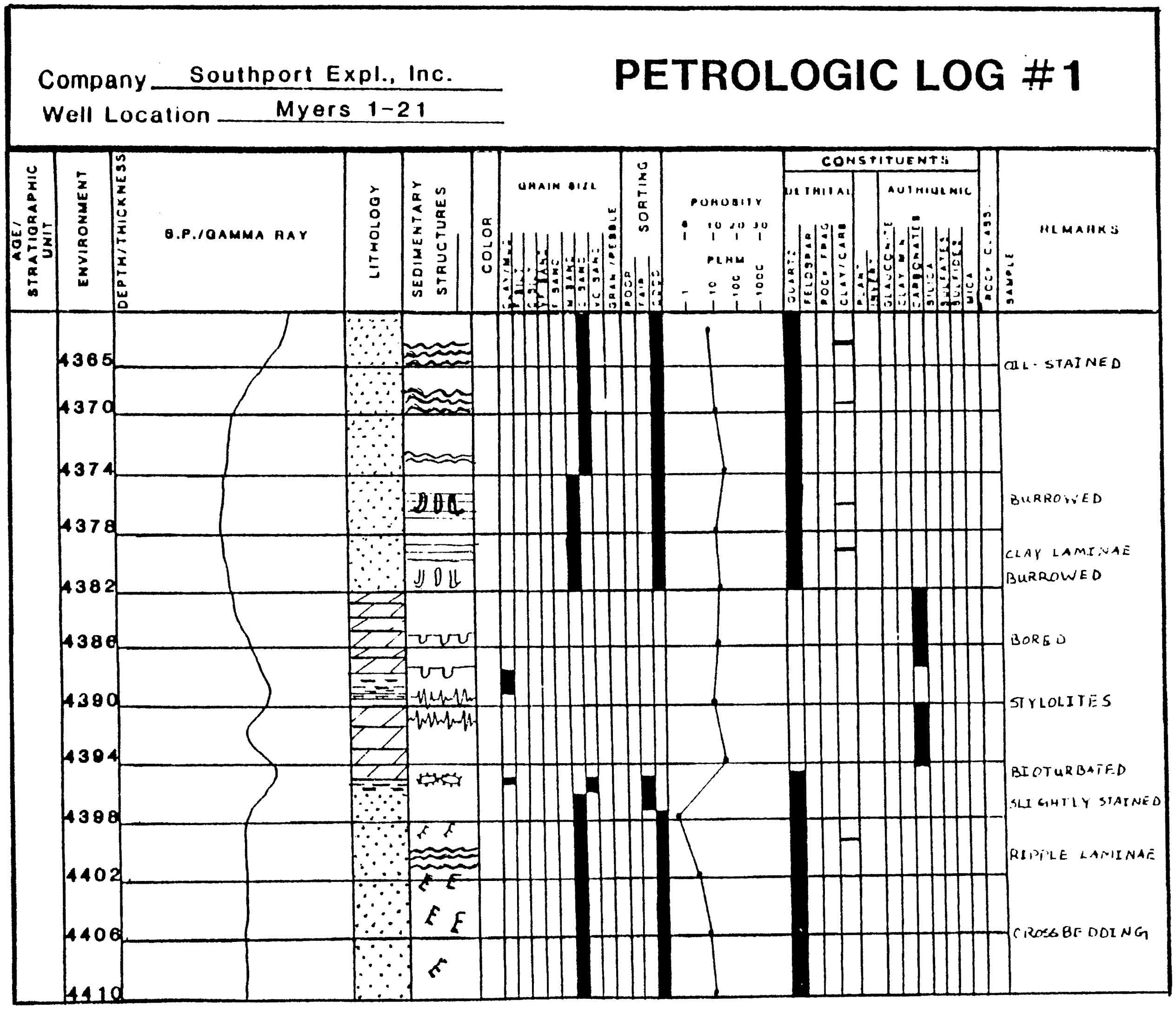
FELDSPAR
ROCK FRAGMENTS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LITHOLOGY
SEDIMENTARY STRUCTURES
COLOR
GRAIN SIZE
SORTING
POROSITY
PERM
CONSTITUENTS
DETRITAL
AUTHIGENIC
REMARKS
4365
4370
4374
4378
4382
4386
4390
4394
4398
4402
4406
4410
OIL-STAINED
BURROWED
CLAY LAMINAE
BURROWED
BORED
STYLOLITES
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SLIGHTLY STAINED
RIPPLE LAMINAE
CROSSBEDDING

Company Southport Expl., Inc.

Well Location Keys 2-22

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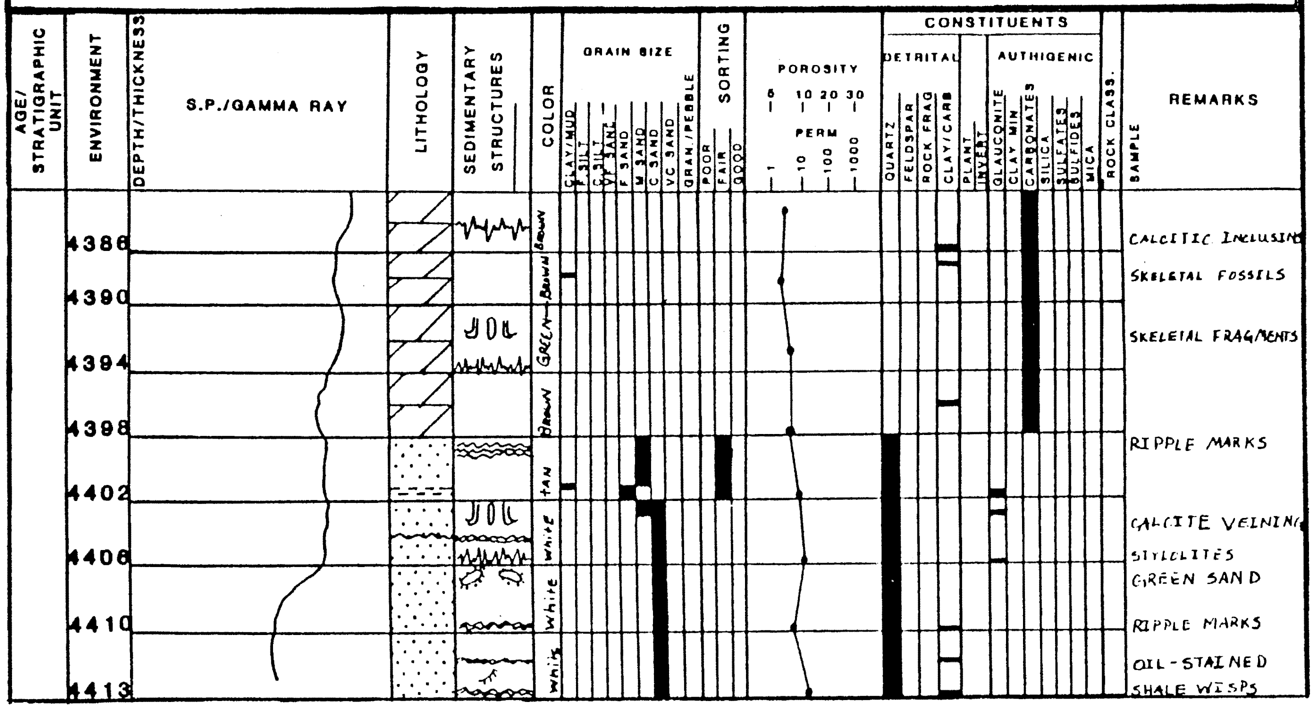

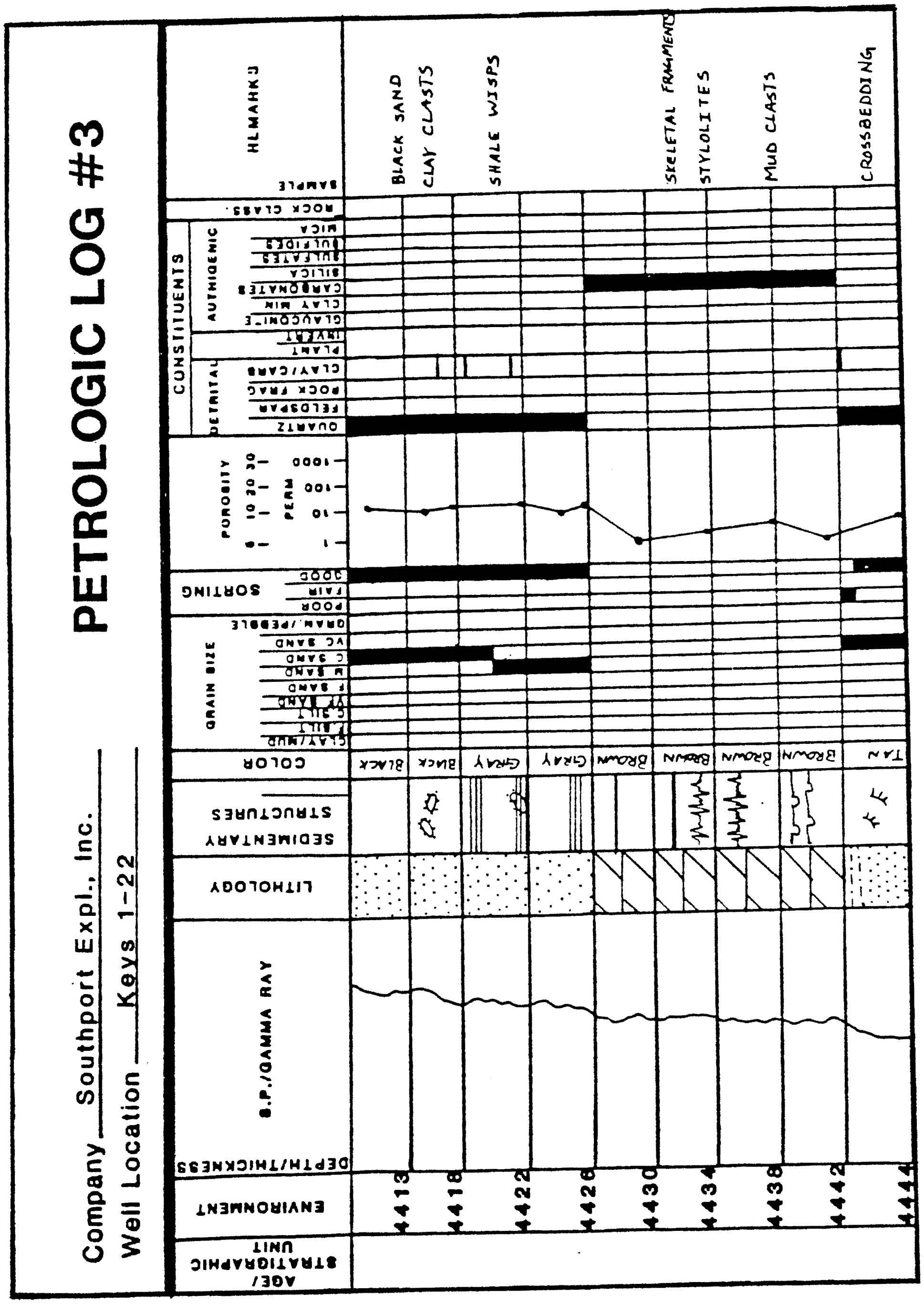
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DEPTH/THICKNESS
S.P./GAMMA RAY
LITHOLOGY
SEDIMENTARY STRUCTURES
COLOR
GRAIN SIZE
SORTING
POROSITY
PERM
CONSTITUENTS
DETRITAL
AUTHIGENIC
ROCK CLASS.
SAMPLE
REMARKS
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BLACK
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GRAY
BROWN
BROWN
BROWN
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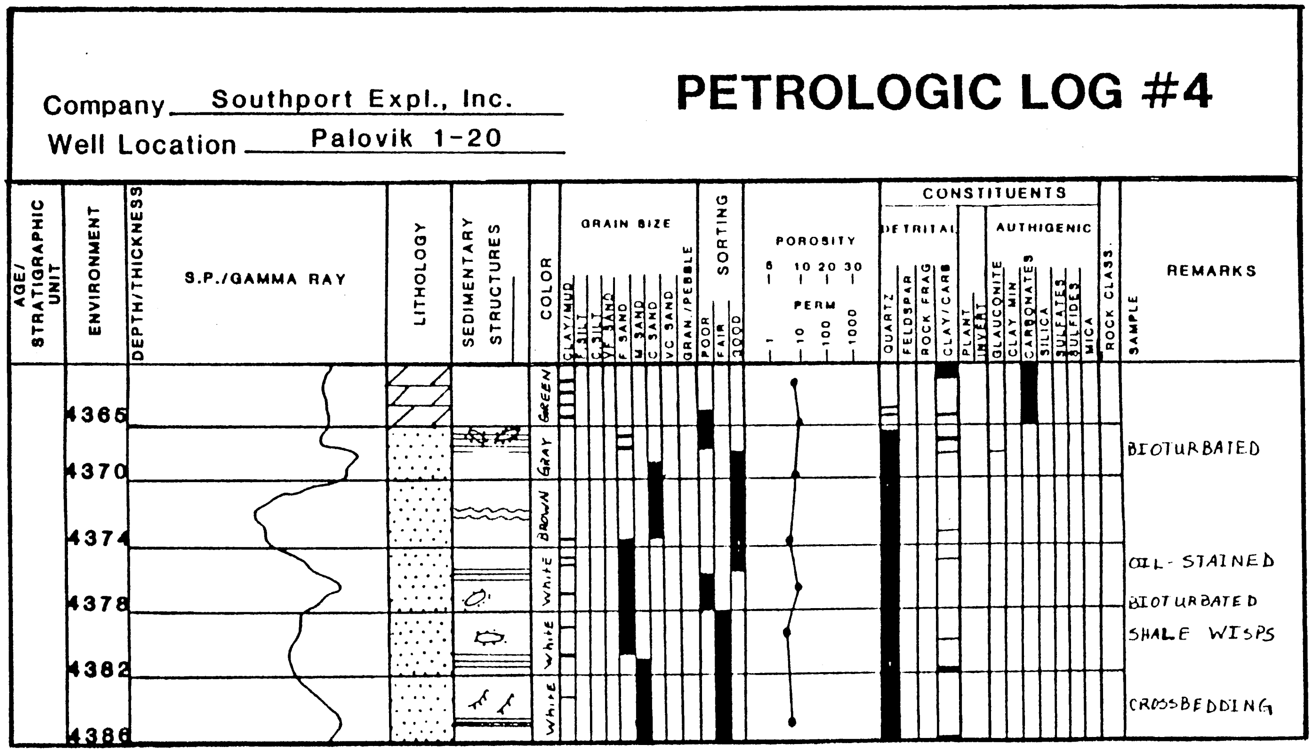
STYLOLITES
MUD CLASTS
CROSSBEDDING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ENVIRONMENT
DEPTH/THICKNESS
S.P./GAMMA RAY
LITHOLOGY
SEDIMENTARY STRUCTURES
COLOR
GRAIN SIZE
CLAY/MUD
F SILT
C SILT
VF SAND
F SAND
M SAND
C SAND
VC SAND
GRAN./PEBBLE
SORTING
POOR
FAIR
GOOD
POROSITY
5 10 20 30
PERM
1
10
100
1000
CONSTITUENTS
DETRITAL
QUARTZ
FELDSPAR
ROCK FRAG
CLAY/CARB
PLANT
INVERT
AUTHIGENIC
GLAUCONITE
CLAY MIN
CARBONATES
SILICA
SULFATES
SULFIDES
MICA
ROCK CLASS.
SAMPLE
REMARKS
4365
4370
4374
4378
4382
4386
GREEN
GRAY
BROWN
White
White
White
BIOTURBATED
OIL-STAINED
BIOTURBATED
SHALE WISPS
CROSSBEDDING

Company Southport Expl., Inc.

Well Location Arrington 1-28

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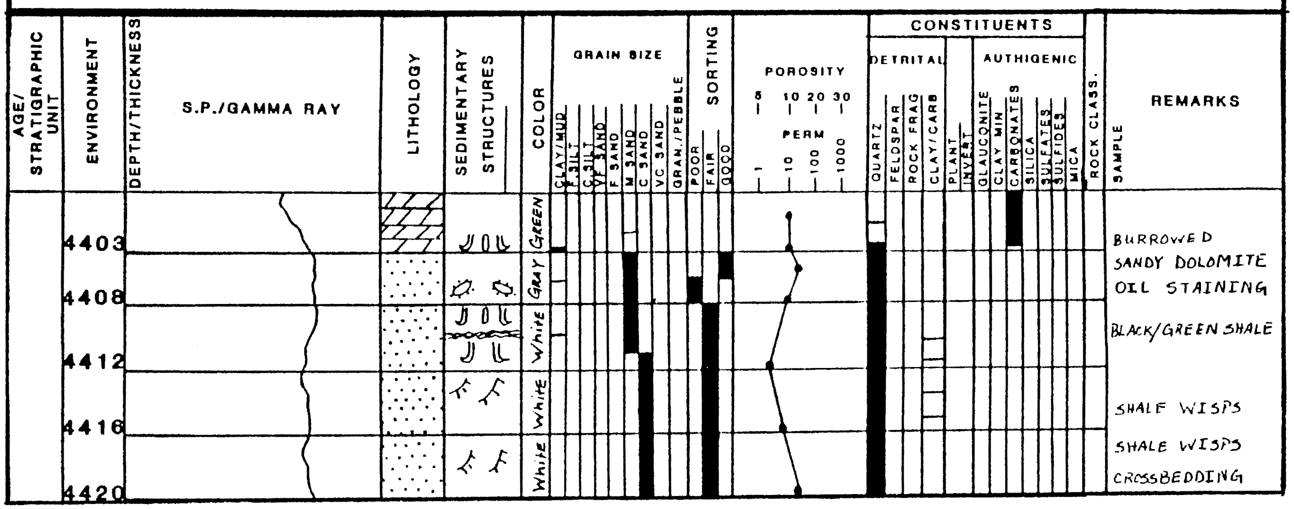

VITA

Brenda Sue Dulaney

Candidate for the Degree of

Master of Science

Thesis: THE "FIRST WILCOX SAND" OF NORTH-CENTRAL PAYNE COUNTY, OKLAHOMA

Major Field: Geology

Biographical:

Personal Data: Born in Midland, Texas, February 9, 1961, the daughter of Mr. and Mrs. W.E. Dulaney.

Education: Received Bachelor of Science Degree in Geology, May, 1985, from the University of Oklahoma, Norman, Oklahoma; completed requirements for the Master of Science degree at Oklahoma State University in May, 1987.

Professional Experience: Summer Project Geologist for Petrodril, Incorporated, Ada, Oklahoma, Summer, 1983; Project Geologist for Professional Geophysics, Inc., Oklahoma City, Oklahoma, August, 1984 to May, 1985; Project Geologist for John Hoard, Petroleum Geologist, Ardmore, Oklahoma, January, 1986 to January, 1987.

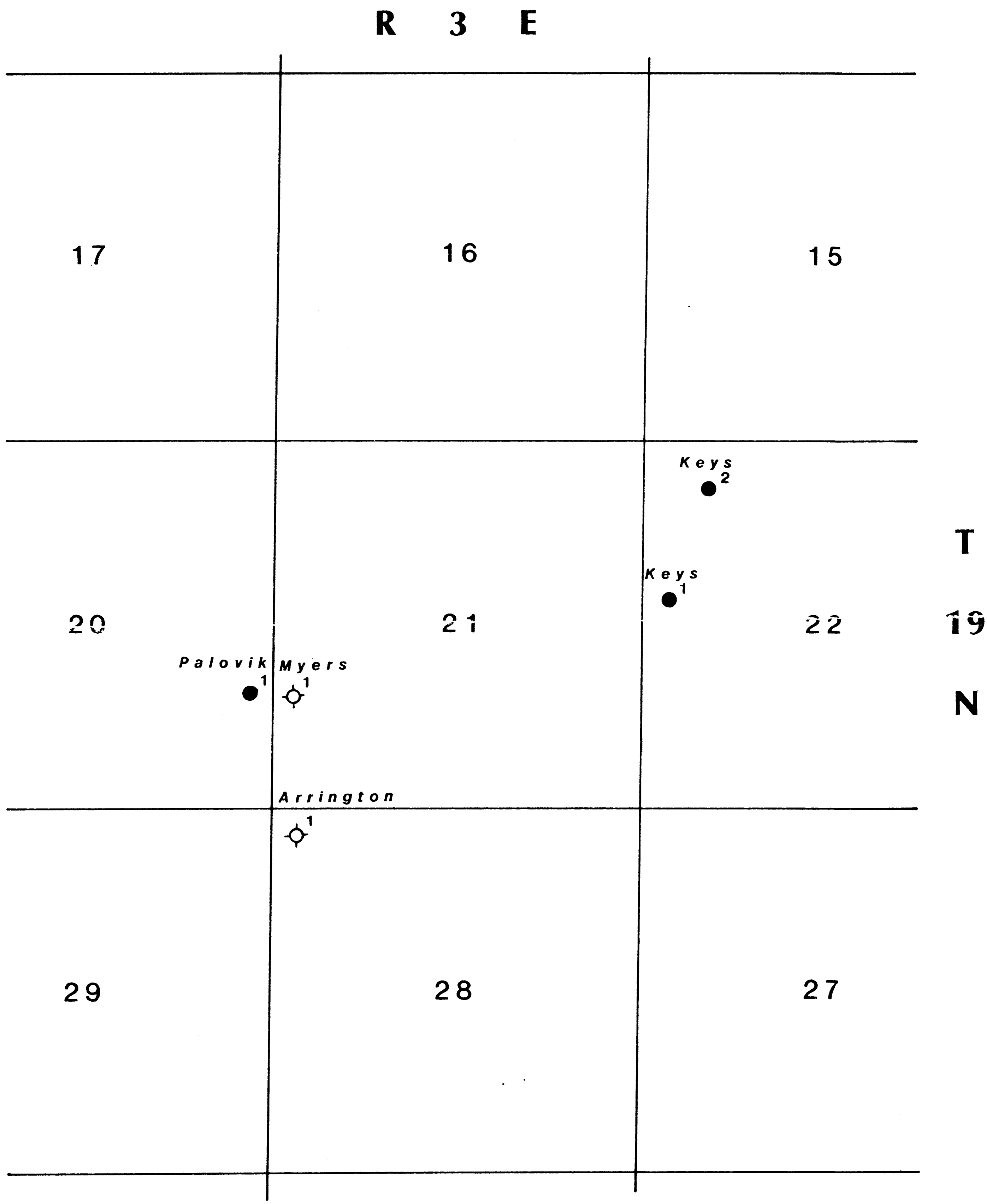


PLATE 1

LOCATION MAP OF CORES

BY: B.S. Dulaney DATE: April, 1987

SCALE: 1" = 2000'


PLATE 2

STRATIGRAPHIC CROSS-SECTION A - A'

DATUM: BASE WOODFORD SHALE

B.S. Dulaney M.S. Thesis 1987
Oklahoma State University


PLATE 3

STRATIGRAPHIC CROSS-SECTION B - B'

DATUM: BASE WOODFORD SHALE

B.S. Dulaney
M.S. Thesis 1987
Oklahoma State University


PLATE 4

**STRUCTURE MAP**

**TOP MISSISSIPPI LIME**

**C.I. = 25'**

BY: B. Dulaney DATE: April, 1987

SCALE: 1" = 2000'

0' 1320' 2640' 5280'

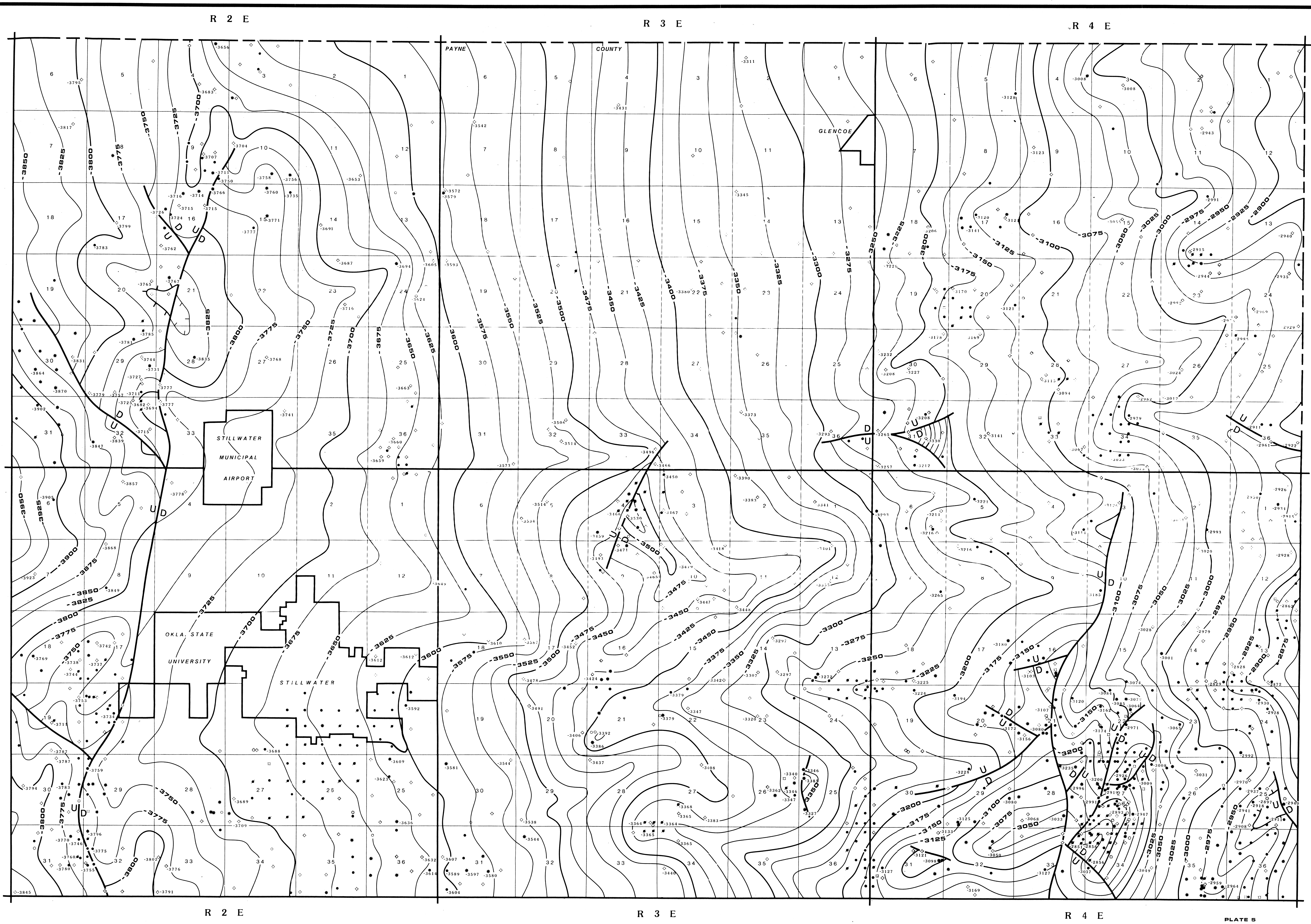


**PLATE 5**

**STRUCTURE MAP**

**TOP VIOLA LIME**

**C.I. = 25'**

BY: B. Dulaney DATE: April, 1987

SCALE: 1" = 2000'

0' 1320' 2640' 5280'

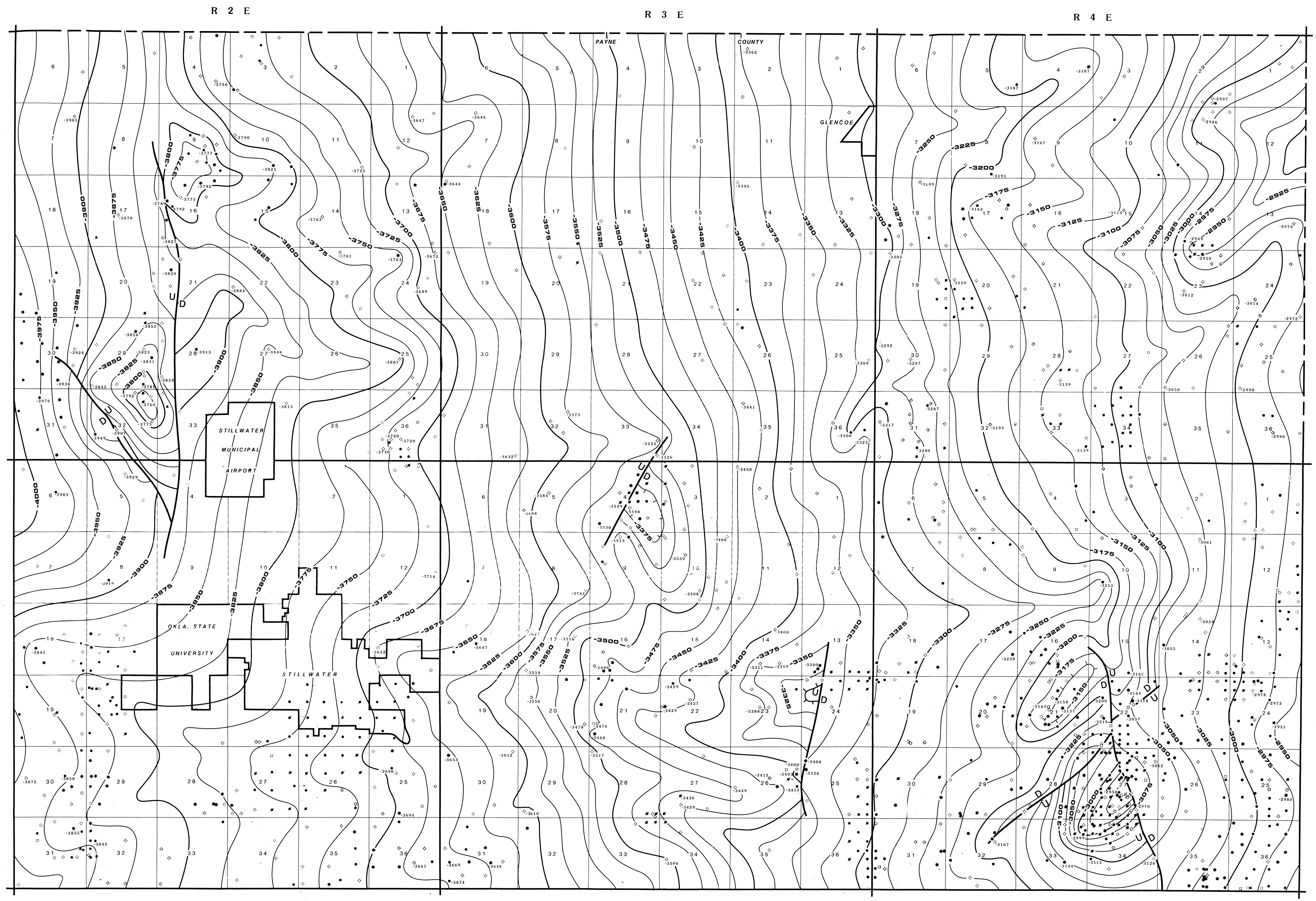


**PLATE 6**

**STRUCTURE MAP**

**TOP FIRST WILCOX**

**C.I. = 25′**

BY: B. Dulaney DATE: April, 1987

SCALE: 1″ = 2000′

0′ 1320′ 2640′ 5280′

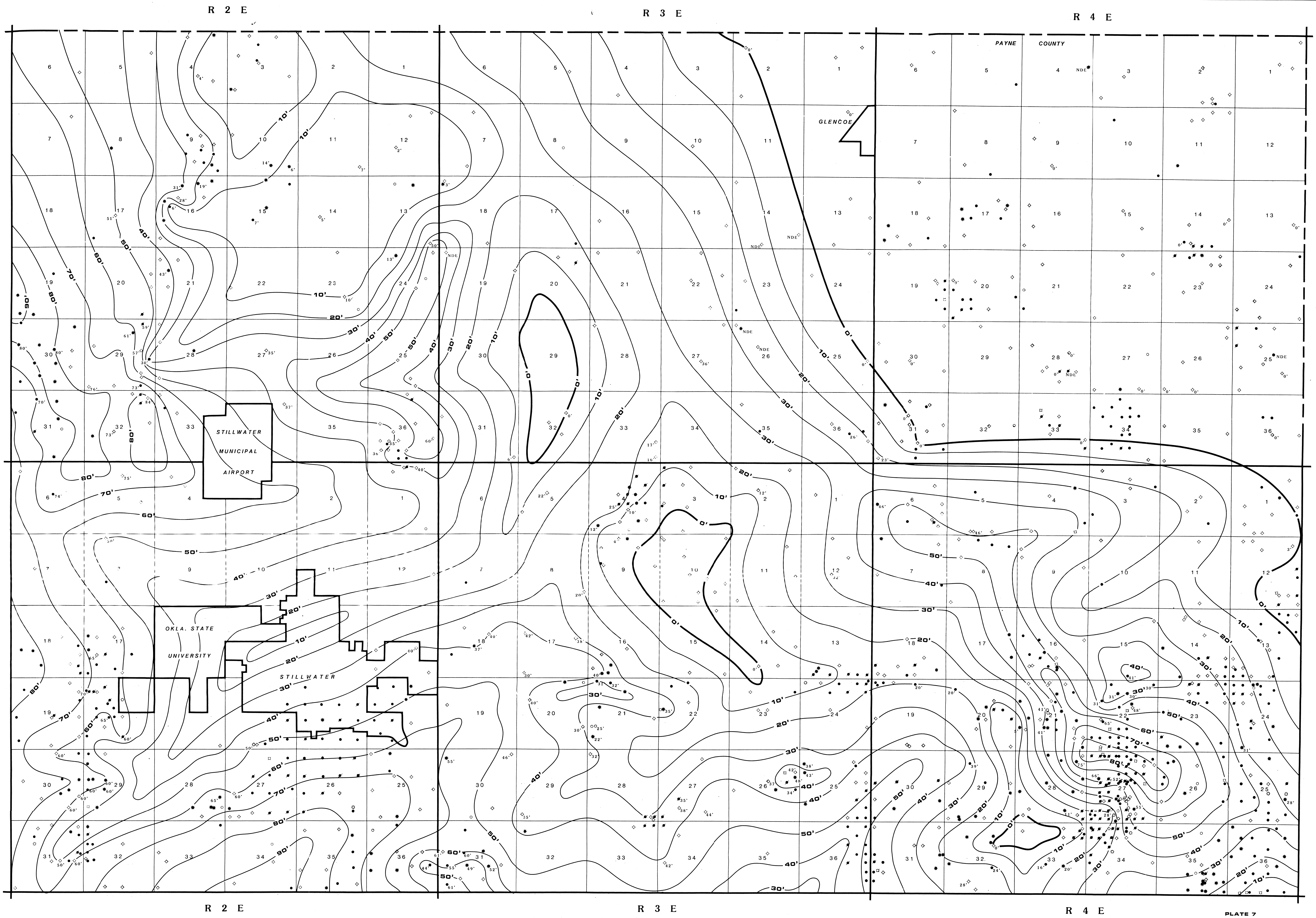


PLATE 7
ISOPACH MAP
SYLVAN SHALE
C.I. = 10'

BY: B. Dulaney DATE: April, 1987
SCALE: 1" = 2000'
0' 1320' 2640' 5280'

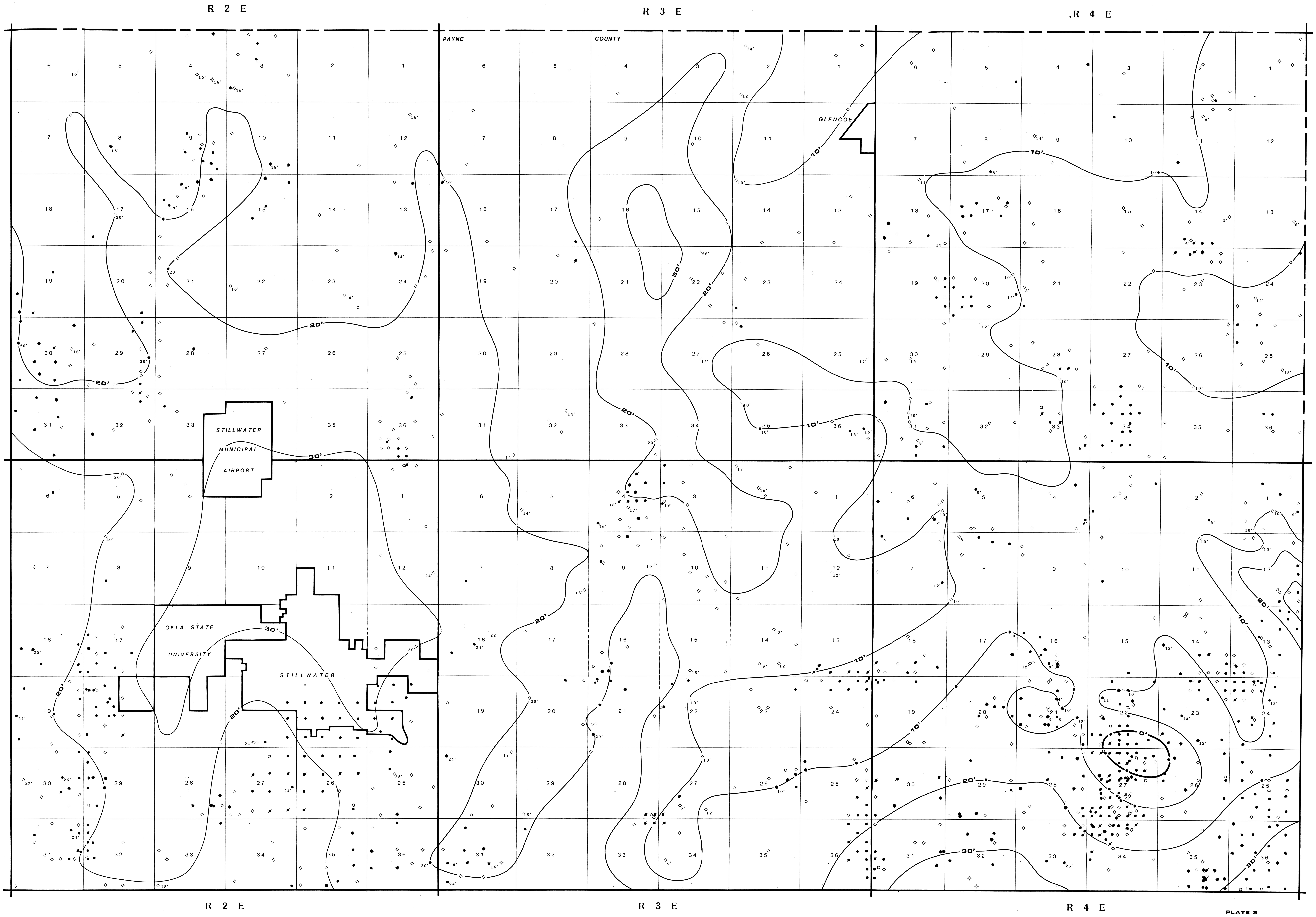


**PLATE 8**

**ISOLITH MAP**

**FIRST WILCOX**

**C.I.=10'**

BY: B. Dulaney DATE: April, 1987

SCALE: 1"= 2000'

0' 1320' 2640' 5280'


PLATE 9

ISOPACH MAP

MISENER/HUNTON/SYLVAN

C.I. = 10'

BY: B. Dulaney DATE: April, 1987

SCALE: 1" = 2000'

0' 1320' 2640' 5280'